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SCIENCE

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Henri Poincaré...on disinterested fools

"But scientists believe that there is a hierarchy of facts, and that we may make a judicious choice among them. They are right, for otherwise there would be no science, and science does exist. One has only to open one's eyes to see that the triumphs of industry, which have enriched so many practical men, would never have seen the light if only these practical men had existed, and if they had not been preceded by disinterested fools who died poor, who never thought of the useful, and who were not guided by their own caprice.

What these fools did, as Mach has said, was to save their successors the trouble of thinking. If they had worked solely with a view to immediate application, they would have left nothing behind them, and in face of a new requirement, all would have had to be done again."

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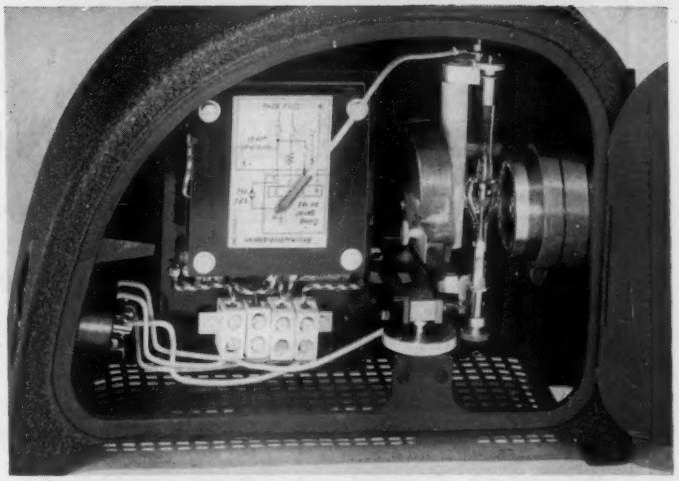

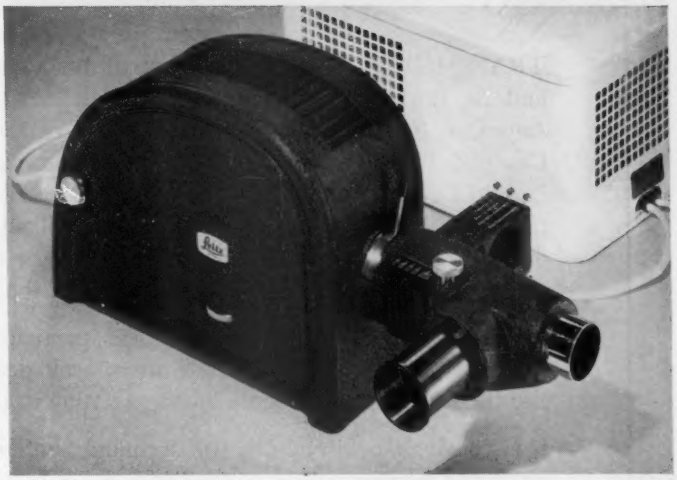

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Published, March 1957

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Introduction by Chauncey D. Leake

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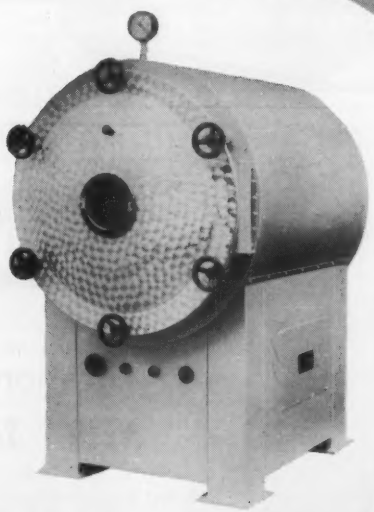

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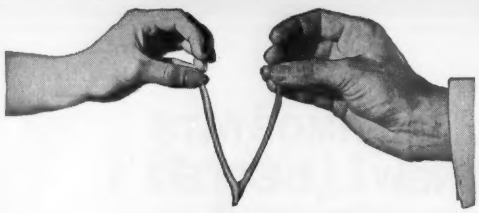

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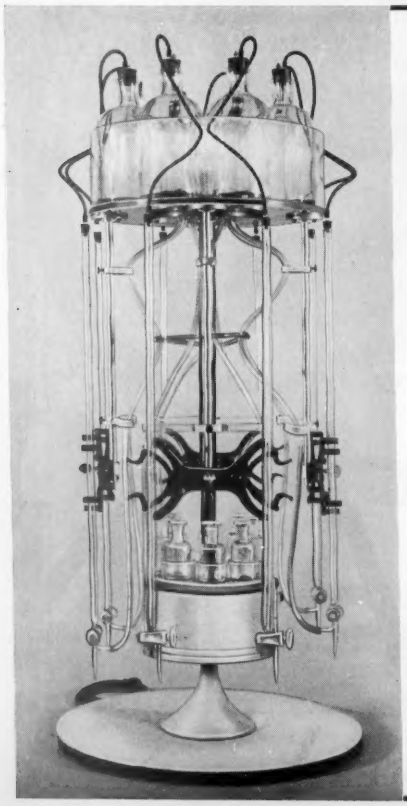

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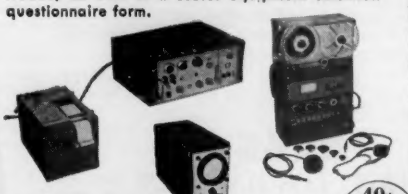

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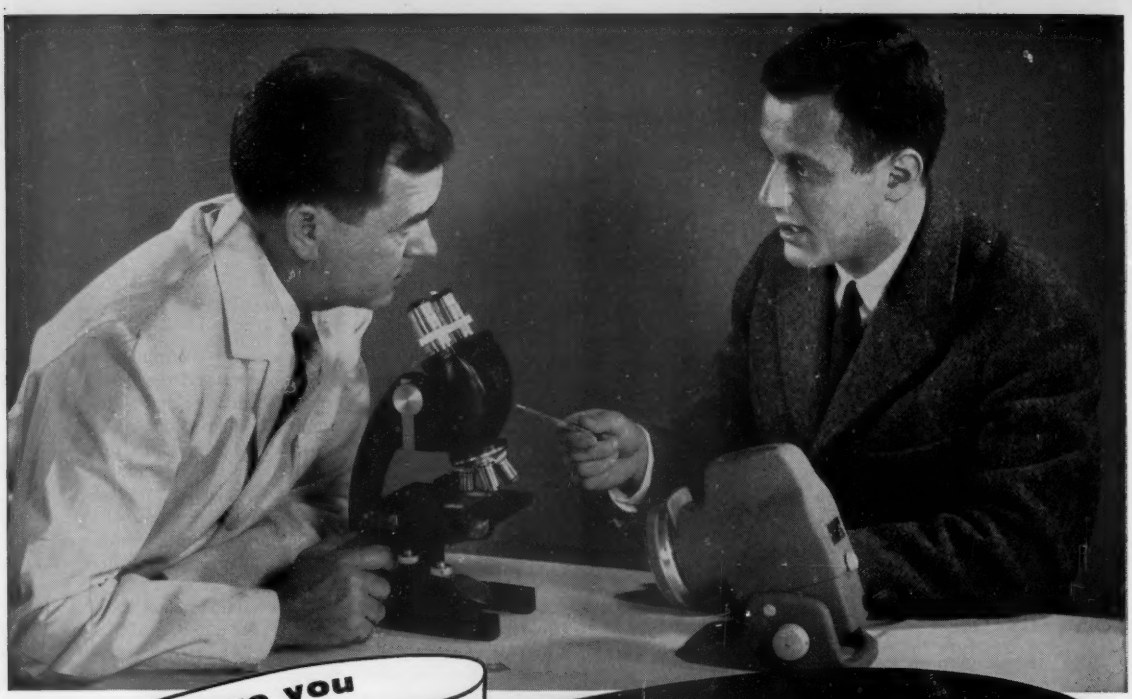
Science Legislation Puzzles

Senators and Representatives have returned to Washington in a mood to "do something" about the support of science and the improvement of science education. Among the proposals—some new and some held over from the last session—the largest number contain provisions for scholarship grants or loans. Others deal with graduate fellowships, direct support of one kind or another for high school science teachers and teaching, for college science laboratories and equipment, for student guidance programs, for increased research support, for an expanded program of translating, abstracting, and disseminating the world's scientific literature, and for consolidating into a Cabinet-level department some of the Federal agencies that have major scientific responsibilities.

Underlying these varied proposals are two fundamental issues on which agreement has not yet been reached. One is the question of how much the grave realities of world conditions require that attention be devoted to attempts to bolster our immediate strength and how much the longer-run needs require that attention be given to improvements that will bear fruit 8 or 10 or more years from now. Emphasis on the immediate problems leads to proposals for missile development, increased support for research, especially applied research, and provision of translating services. Emphasis on the future leads to proposals for the improvement of education and the encouragement of larger numbers of able college entrants. This issue is likely to be settled by doing some of both, for while there is wide agreement that immediate steps are essential, there is also much conviction that longer-term efforts must also be undertaken.

It is in these longer-term efforts that the second issue arises. It is this: How much emphasis should be concentrated on improving instruction in science and mathematics and how much on improving education generally? Considerable compromise is likely to be necessary before this question is answered. On the one hand, it is widely held that education in science and mathematics has fallen behind education in other fields at the secondary school level and that special efforts would restore rather than disturb educational balances. It is also argued that special emphasis is justified when special needs are so clearly apparent. On the other hand, it is feared that we may attempt to make scientists out of students who have no aptitude for science, that we are likely to overemphasize science to the detriment of other vitally important fields, that we may even overemphasize the physical sciences to the detriment of other scientific areas. These differences of judgment may have to be resolved on specific proposals rather than in general terms. Most scientists and educators agree that undergraduate scholarships should be awarded on the basis of ability rather than on the basis of the prospective field of specialization. Yet persons who hold this view may agree that in the high school the teaching of science and mathematics merits special support because of the rapid changes that are taking place in these fields, the more acute competition for persons with a good knowledge of these fields, and the resulting difficulties of securing an adequate number of well qualified teachers.

It is a matter of considerable urgency to reach substantially greater agreement than now exists upon the actions that appear to be of greatest importance. Agreement among scientists will not guarantee adoption of the ideas upon which they have agreed, but lack of agreement will increase the confusion and seriously weaken the opportunity to secure sound legislation.—D.W.



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International Geophysical Year

A Report on the United States Program

Hugh Odishaw

The International Geophysical Year began on 1 July and will continue through all of 1958. This article presents a brief account of some of the activities during the first five months, 1 July to 30 November 1957.

Although this account is primarily concerned with the United States program, some references are made to the activities of other participating countries. It should be noted that 67 countries are cooperating in this study of the earth and its cosmic environs; the types of work described here are also being conducted by other national IGY groups. For convenience the IGY investigations may be classified under three categories: (i) the physics of the upper atmosphere, (ii) the earth's heat and water regimen, and (iii) the earth's structure and interior. Subjects in the first category include solar activity, aurora and airglow, cosmic rays, ionospheric physics, and geomagnetism. This category also includes rockets and satellites, tools for sending instruments into the upper atmosphere. Subjects in the second category include meteorology, oceanography, and glaciology, and those in the third include seismology, gravity, and determinations of longitude and latitude.

The following sections report briefly the activities in each of the fields in each of the three categories. A final section outlines aspects of the collection and interchange of data in the IGY program.

Physics of the Upper Atmosphere

Solar Activity. As particles radiated from the major solar flare of 28 June 1957 began to arrive at the earth, two days later, a storm wracked the earth's magnetic field. The ionosphere—the layer of electrically-charged gas between about 40 and 200 miles above the earth's surface—was torn by electrical disturbances; long-range radio communication was blacked out for a long period of time. The flare was first observed at the Krasnaya Pakhra Observatory in the Soviet Union. Immediately a message was flashed to the World Warning Agency operated for the IGY by the National Bureau of Standards at Fort Belvoir, which declared a state of "alert," beginning at 1600 Universal Time, 28 June. Alerts are declared when there is probability of solar disturbances. When the possibility is high that terrestrial disturbances will also occur, Special World Intervals are promulgated, calling for an increased number of measurements of solar-terrestrial phenomena. The first such interval in the IGY was declared 29 June, to commence at 0001 Universal Time on 30 June. Throughout the world observations of the sun were intensified, and balloons and instrumented rockets were sent up by many nations to observe the increased ultraviolet and x-radiation and to monitor cosmic ray intensity. Observations and measurements were speeded up to record more carefully and fully the northern and southern lights, to measure disturbances in the earth's magnetic field, and to probe the ionosphere.

During periods of maximum solar activity radio communications are often interrupted by "fadeouts" or "blackout," particularly after the occurrence of a flare on the sun. On these occasions pulses transmitted to the ionosphere by ionospheric sounders are not reflected as usual but are absorbed. It had long been thought, but not heretofore conclusively established, that this absorption must be caused by increased ionization in the lower atmosphere. On 4 July, radio signals received from a rocket fired up through the ionosphere demonstrated the presence of an additional layer of ionization extending for about 12 miles below the normal lowest point. Even more remarkably, the rocket data showed that the normal ion distribution throughout the ionosphere above the D, or lowest, layer, seemed to remain undisturbed during the blackout. In another recent IGY rocket experiment, it was ascertained that the additional electron layer was caused by solar x-ray emission associated with the occurrence of solar flares.

Rockets are only one means of studying solar phenomena. Solar astronomers have organized themselves in a worldwide solar patrol, keeping watch on the sun all over the world throughout the 24 hours of the day. Solar observation stations are operated by 33 countries; of 126 stations all over the world, 14 are operated by the United States, not including rocket-firing sites.

By observing the sun through special filters which limit transmission to the light of certain radiations of hydrogen or calcium, astronomers look for the giant eruptions or flares on the sun which are responsible for radio blackouts, auroras, and magnetic storms. Very narrow band filters are used, since the flares would otherwise be invisible against the bright surface of the sun.

Special instruments are also in use to photograph the chromosphere of the sun, a shell of very incandescent gas just above the sun's surface, and the corona, an envelope of gas that may extend all the way to the earth. The chromosphere and corona are invisible except when an eclipse shuts off the light of the disc, or when the sun is artificially eclipsed in a special telescope called the coronagraph. Using the coronagraph, scientists are able also to photograph solar flares at the edge of the sun; these flares sometimes shoot out into space for

The author is executive director of the U.S. National Committee for the Internatoinal Geophysical Year of the National Academy of Sciences, Washington, D.C.

several hundred thousand miles at very high speeds.

At Mount Wilson Observatory in California, measurements are being made of the magnetic field of the sun at its surface. It has already been found that magnetic fields at the sun's surface may be very high, as much as 8000 times that of the earth's field at the equator. These magnetic fields are thought to play a very important role in disturbances and storms on the sun's surface as well as in sunspots.

Geomagnetism. Thirty countries throughout the world are operating 129 magnetic observatories, from the North to the South Pole and in almost every region of the earth's surface; 31 of these stations are part of the United States program in geomagnetism.

Newly established United States IGY geomagnetic stations are in operation in the Arctic, in the Pacific Ocean, in continental United States, and in South America with the cooperation of IGY scientists in Peru. Certain of these stations are set up in chains, with carefully planned spacing, to study in detail the magnetic storms which occur during great solar disturbances. It has been suggested, but not before positively established, that the magnetic effects we observe on earth during magnetic storms may be due to great electric currents, of perhaps several hundred thousand amperes, flowing around the earth high in the atmosphere. Two of these currents are believed to circle the North and South magnetic poles, while the third circles the earth at the geomagnetic equator. This theory is being examined.

The stations in South America and in the Pacific Ocean—at Guam and Koror in the Western Pacific and at Jarvis, Palmyra, and Fanning islands in the Eastern Pacific—were established especially to study the existence of the so-called "electro-jet." The electro-jet is believed to be the equatorial electric current, but narrowed down into a "neck" of limited horizontal dimensions with consequent increased current density and intensified activity at local noon. The U.S. Coast and Geodetic Survey, which operates many of the magnetic observatories established by the United States, reports tentative confirmation of this phenomenon. Initial data from Koror reveal the existence of the equatorial electro-jet and its rather limited horizontal extent.

Aurora and airglow. A world-wide comprehensive auroral observation program in 49 countries is under way for the first time during the IGY. Many of these 49 countries are in low latitudes where auroras are seldom seen. Nevertheless, in all of them, auroral reporters have been appointed to collect reports of visual observations in the event that a very great aurora should occur. A number of such auroras have been reported in the last century, but these events of great scientific importance have usually been inadequately described. One hundred and forty-two camera and instrumental auroral observation stations, as well as extensive amateur visual observing programs, have been organized in 17 countries.

The 39 stations and hundreds of amateurs participating in the United States program have already had much to observe. The fact that the IGY was scheduled for a period of expected maximum solar activity has greatly enhanced the value of the program, for already three of the largest solar flares (class 3+) have resulted in extensive auroral displays visible as far south as Havana, Cuba. Synoptic maps have been prepared depicting all auroras observed and reported from the United States during the months of July and August. This is the first time that such a complete description of auroral data has been assembled for the use of geophysicists studying auroral and such related phenomena as ionospheric and geomagnetic effects.

English scientists at the University of Manchester have reported that simultaneous radar observations indicate that auroras occur simultaneously in the Northern and Southern Hemispheres, a condition long believed to be true by scientists, but not previously established. Additional polar radio data which provide further evidence on this question have been obtained in the United States program.

The systematic reduction of the variations in the intensity of the night air-

Parabolic antenna, with aurora borealis in the sky, used at College, Alaska, to study radio noise and radio wave reflections from the aurora. [Stanford Research Institute]

First IGY scanning photoelectric photometer, situated on top of Fritz Peak, near Boulder, Colorado. This instrument selects and measures the intensity of light too faint for the human eye to detect and records its changes, converting the light into electric signals. [National Bureau of Standards, Boulder Laboratories]

glow is proceeding. Charts of the "patchiness" and movement of night sky luminosity resulting from oxygen emissions are being produced on a routine basis from IGY observations.

Ionospheric Physics. One of the major problems in ionospheric physics is predicting the future state of the ionosphere. If we can determine the condition of the ionosphere in advance, we can do much to develop more reliable radio communications, with direct rewards in safer travel in the air and at sea. Forty-one nations are conducting studies of the ionosphere during the IGY, and a world-wide network of 253 ionospheric observing stations has been established. Seventy-one of these stations are sponsored by the United States. The data obtained by the network will provide a world-wide picture of the behavior of the ionosphere.

New information about the farthest reaches of the atmosphere is being obtained from the study of "whistlers"—whistlelike sounds which can be detected at very low radio frequencies. These signals, originating in lightning flashes at the surface of the earth, swing out thousands of miles along the earth's lines of magnetic force before they return to the opposite polar hemisphere. Early IGY experiments demonstrated that the ion density and molecular concentration along the whistler path at altitudes of as much as twice the earth's radius must be much greater than formerly anticipated. Indeed, there seems to be confirmation for the theory that the earth's atmosphere extends far beyond the level where it had been previously thought to "end" and that there may be a very tenuous atmosphere—the sun's corona—filling all the space between the earth and the sun.

Other records of previously unexplained radio noise at very low frequencies have stimulated the hypothesis that solar particles arriving in the very high atmosphere transfer energy to very low frequency radio waves there. According to this hypothesis, the radio signals thus amplified are the very low frequency radio emissions observed at ground level. Data now being gathered will throw further light on this hypothesis, which is based on the traveling wave tube principle noted by Roger Gallet.

Ionospheric characteristics are deduced from the analysis of echoes arising from the reflection of radio pulses transmitted to the ionosphere at vertical incidence. Since the IGY began there have been several major solar events that caused disruption of long-range, short-wave radio communications which depend upon reflections from the ionosphere. For the first time, a synoptic picture has been obtained of the growth and decay, station by station, of such fade-outs.

The principal regular variation in the

ionosphere is the diurnal one. Ionization density increases during the day when the sun is present and decreases at night. What would happen to the ionosphere during long absences of solar radiation and the nature of any diurnal variation that might occur during such periods have been subjects of speculation. Only at or near the geographical poles can these questions be examined, and the South Pole affords the best platform for an observatory. Investigations during the last year at the United States' South Pole Station have yielded interesting results: in spite of the absence of the sun, the electron concentration seems to remain very high throughout the polar night; moreover, there is a diurnal variation that can only, it appears, be associated with geomagnetic activity. The evidence so far obtained suggests that ionospheric behavior in the two polar regions is essentially the same. Analysis of these observations may appreciably alter our concepts of the ionization and recombination processes in the atmosphere.

Cosmic Rays. Cosmic rays are electrically charged particles which bombard the earth continuously and from every direction. Although their existence has been known for fifty years, their source and precise nature remain uncertain. In particular, the source of these particles is one of the major questions in astrophysics, and the answer is one of major importance in understanding the cosmos from which the rays take their name. These particles, consisting largely of nuclei and having energies ranging from 10^8 to 10^{19} electron volts, are influenced by the earth's magnetic field. Low-energy particles are deflected toward the vicinity of the two geomagnetic poles, and only the more energetic ones penetrate at the middle latitudes.

During the IGY, the scientists of 31 nations are studying cosmic rays at 195 stations; neutron monitors and meson telescopes, cloud and ionization chambers, special photographic emulsions, and window Geiger counters are being used. Rockets and balloons, as well as earth satellites, are important tools for observing these rays. Typical of international cooperation during the IGY is the Swedish-Canadian-American cosmic ray experiment carried out aboard the Swedish merchant ship *M/S Lommaren,* sailing between Sweden and the Union of South Africa.

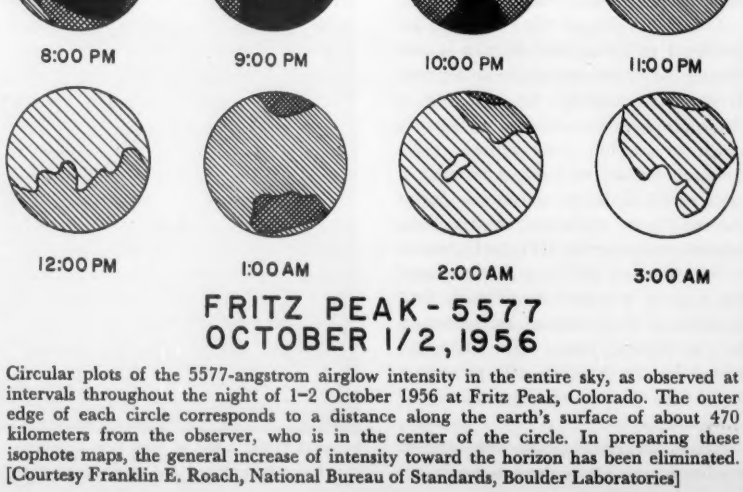
Investigations at the 20 United States cosmic ray stations have already provided interesting results. The work of scientists from the University of Chicago has shown that the location of the line where the cosmic ray intensity is at a minimum—the "cosmic ray equator"—deviates systematically from the geomagnetic equator. The experiments leading to this result began in 1954–55 when a neutron pile detector was installed aboard the *U.S.S. Atka,* which conducted a reconnaissance of the Antarctic prior to the establishment of IGY stations in following years. Measurements were made on the trip down to and around Antarctica and back; these measurements were repeated aboard the *U.S.S. Arneb* during the 1955–56 and 1956–57 seasons in Antarctica and were supplemented by aircraft flights in a zigzag pattern around the geographical equator, in October 1956. These studies showed a 40- to 45-degree westward shift of the inclined cosmic ray equator with respect to the magnetic equator. J. A. Simpson suggests that this warping may well indicate the presence of important magnetic fields, probably of extraterrestrial origin, which alter the trajectories of the incoming primary cosmic ray particles.

Preliminary balloon flights in and near Minnesota with balloons that carry ionization chambers have shown that, at constant altitude, there is a strong latitude effect. This effect is so strong that changes in latitude of as little as 7 miles can be detected by cosmic ray measurements. Other balloon experiments, at Fort Churchill and Thule, have shown that cosmic rays of lower energy (less than about 2 Bev) have essentially disappeared during the present period of high solar activity, with ionization at high altitudes down to half the value it had in 1954 or 1955.

Perhaps one of the most interesting observations made in the course of IGY cosmic ray experiments was that of relatively soft radiation in the high atmosphere, associated with primary auroral radiations. Rocket and balloon flights have led to the positive identification of the soft radiation: it is x-radiation in the range between 10^4 and 10^5 electron volts. There appears to be good correlation between the presence of such radiation and solar, magnetic, and auroral activity. The effect is probably a secondary one; it is believed that incoming auroral particles create the x-rays by bombardment of atmospheric particles.

Rockets and satellites. Rockets provide one of the two important ways of directly measuring phenomena and processes in the upper atmosphere. Rockets are, moreover, unique in that they permit studies of the altitude-dependence of various quantities and events—for example, temperature, pressure, density, and composition. Seven nations are engaged in rocket programs: Australia, Canada, France, Great Britain, Japan, the United States, and the U.S.S.R.

Some 200 rockets are involved in the United States rocket effort. Firings are under way in the Arctic, Antarctic, Pacific, and continental areas. A major facility at Fort Churchill, Manitoba,



Circular plots of the 5577-angstrom airglow intensity in the entire sky, as observed at intervals throughout the night of 1–2 October 1956 at Fritz Peak, Colorado. The outer edge of each circle corresponds to a distance along the earth's surface of about 470 kilometers from the observer, who is in the center of the circle. In preparing these isophote maps, the general increase of intensity toward the horizon has been eliminated. [Courtesy Franklin E. Roach, National Bureau of Standards, Boulder Laboratories]

within the north auroral zone, was constructed in cooperation with Canada, and a joint Canadian-United States program is under way.

There were 29 rockets fired in the pre-IGY test period. These included Aerobees, Rockoons and Nike-Cajuns. Firings took place at the newly erected facilities at Fort Churchill as well as at White Sands (New Mexico) and Guam, and from shipboard off the California coast and in the North Atlantic. These firings were successful, and the preliminary information gained was of considerable value in the final detailed planning of the schedules for firings during the IGY period.

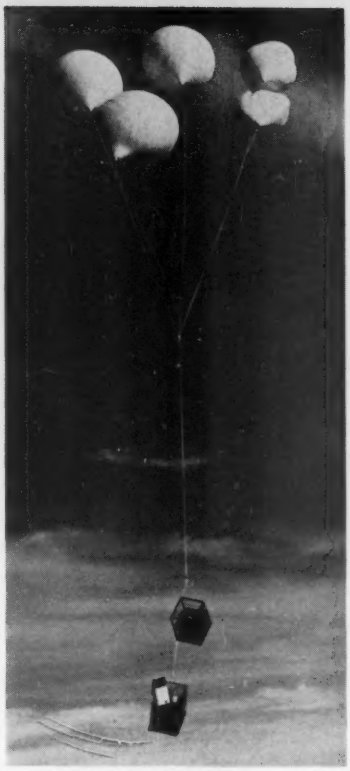
The United States IGY program in rocketry actually began on 5 July 1956 at Wallop's Island, Virginia, when the first IGY test rocket was fired successfully. To date, 81 rockets have been fired during the IGY. Included have been those in programs conducted at Fort Churchill (nine Aerobees, five Nike-Cajuns); White Sands (two Nike-Cajuns); Point Mugu, San Nicolas Island, California (13 Nike-Deacons); a shipborne operation in the Arctic (18 Rockoons); and a shipborne operation in Pacific and Antarctic waters which was concluded in mid-November (36 Rockoons). The following are some preliminary findings:

1) A firing at Fort Churchill indicated that the first atmospheric temperature maximum occurred at an altitude of about 60 kilometers. Normally this maximum is found below 50 kilometers at lower latitudes, indicating that, at northern latitudes, the rise is more gradual. (Temperatures decrease up to the stratosphere, rise during the next 20 to 30 kilometers, decrease through the next 30 kilometers, and then rise again.)

2) A rocket, instrumented for ionospheric studies, was sent through a polar blackout for the first time. Data were obtained which indicated that a very dense D-region exists at a significantly lower altitude, and with a much greater density, than is found at lower latitudes.

3) A firing at Fort Churchill during the summer of 1957 measured electron distribution in the ionosphere up to an altitude of 250 kilometers during a polar blackout. The results of this experiment confirmed theories that the D-region of the ionosphere is primarily responsible for radio blackouts.

4) During a series of firings with Aerobees and Nike-Cajuns instrumented for studies of pressure, temperature, and density, it was determined that the distribution of pressure and temperature in the atmosphere at high latitudes is very different from what it is at lower latitudes. Many of these rockets attained altitudes greater than 200 kilometers, and thus the first density measurements made at high latitudes were recorded. Launchings were made during both summer and winter, day and night. The resulting data indicate that the density of the high atmosphere is under strong solar control. There appear to be a latitude effect, a seasonal effect, and a strong diurnal effect; none of these effects appear at lower altitudes at Fort Churchill or lower latitudes.



A group of small weather balloons used to test a timing device prior to the use of similar devices on Deacon rockets to measure cosmic radiation and the temperature, density, and pressure of the upper atmosphere. [U.S. Navy]

5) An experiment with a mass spectrometer at Fort Churchill appears to confirm the belief that diffusive separation of gases under gravity is present above 100 kilometers at that latitude. Below this point the gases in the atmosphere appear to be well mixed.

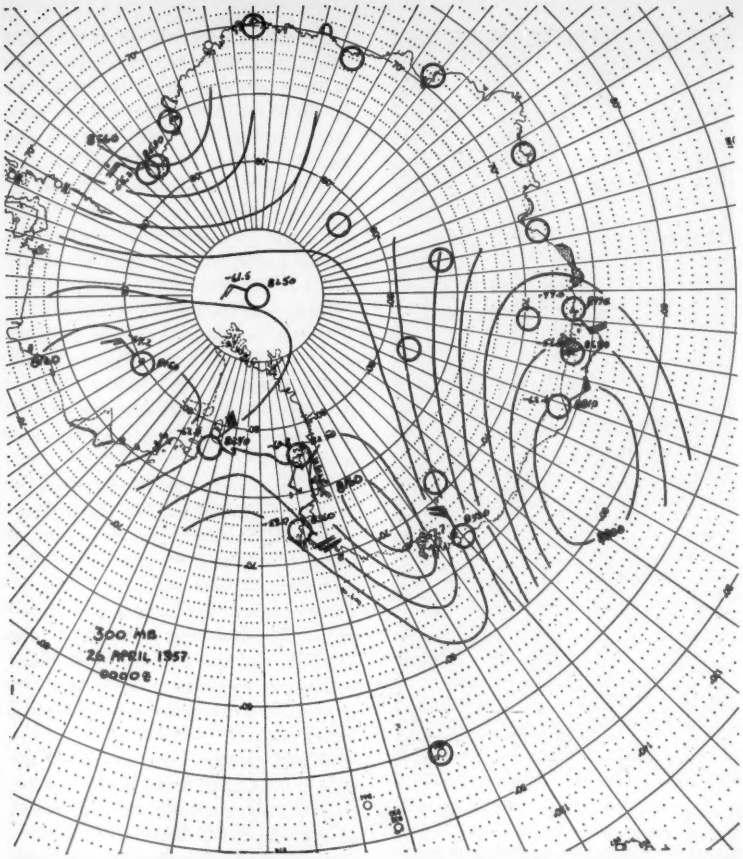
6) During July and August 1957, the DAN rocket flare patrol program took place at Point Mugu, California. This program was primarily directed toward determining the radiation source of the fadeouts resulting from flares observed on the disc of the sun. For the first time, measurements were made of x-ray and ultraviolet bursts from the sun during a solar flare. These data will help in explaining radio blackouts, which are present during periods of unusually high degree of ionization, and which are closely associated with solar flares.

7) During the shipboard firings in the Arctic, an excellent survey was made for the first time of auroral particles and their association with actual aurorae. Also conducted for the first time at high latitudes were magnetic field measurements.

Satellites represent an extension of rocketry useful in probing the high atmosphere. Satellites provide means to secure data on the variation of phenomena with time and over a vast expanse of space. Two nations are engaged in satellite-launching programs: the U.S.S.R. and the United States. Many nations are cooperating in tracking and ground-based observations. In the United States program, precision radio and optical stations have been established not only in the United States but in 13 other countries whose scientists are cooperating closely with the United States scientists.

The U.S.S.R. launched its first satellite on 4 October 1957. This satellite, a sphere nearly 23 inches in diameter and weighing about 184 pounds, carried transmitters broadcasting on frequencies of 20 and 40 megacycles per second. The second Soviet satellite was launched on 3 November. Weighing about 1120 pounds, the last rocket stage was reported to carry two transmitters (20 and 40 megacycles), a dog, and instruments to measure satellite temperatures, ultraviolet light, x-rays, and cosmic rays. The initial period of the second satellite's revolution was 103.7 minutes, with an apogee of approximately 1056 miles and perigee of about 150 miles.

The United States program is proceeding according to schedule. The Navy has responsibility for the rocket system and launching in the Vanguard series; the Army, for the Jupiter-C series. The IGY Committee of the National Academy of Sciences is responsible for the scientific aspects for both the internal experiments and the radio and optical observation programs. Two types of satellites have been designed: test spheres for use during the test period for the Vanguard rocket system and equipment-laden satellites for use there-



Atmospheric circulation at the 300-millibar level at 0000 Greenwich Mean Time, 26 April 1957, based on Weather Central data. Heights are given in meters above sea level; temperatures are in degrees centigrade; arrows show the direction of the wind; wind speed is indicated by one full barb for each 10 knots and by a filled-in flag for 50 knots. [U.S. Weather Bureau]

The Rawin tower at the Little America IGY Station housing radar equipment for tracking meteorological balloons. [U.S. Navy]

after for both the Vanguard and Jupiter-C vehicles.

The test spheres are 6.4 inches in diameter and weigh 4 pounds. They have six 12-inch antennae and six solar cells mounted on the skin. These spheres are designed primarily to transmit signals for radio tracking purposes; they carry two separate transmitter systems operating on frequencies of approximately 108 megacycles. One is battery-powered, while the other is powered by the six solar cells, affording the prospect of indefinite transmitter life.

The IGY equipment-laden satellites have three main configurations. All but two are 20-inch spheres constructed primarily of magnesium, weighing 21.5 pounds, and equipped with four 29-inch antennae. Of the other satellites, one is a sphere approximately 13 inches in diameter, with a protruding cylinder approximately 13 inches long and 2.5 inches in diameter; this satellite will be accompanied by an inflatable sphere, 30 inches in diameter and weighing less than 0.7 of a pound, which will be ejected from the carrier rocket at the same time as the satellite is released. The last configuration, a cylinder to be launched in the Army vehicle (Jupiter-C), is of approximately the same weight as the spherical satellites to be launched in the Navy Vanguard rocket.

Equipment carried by these satellites will include instruments to measure the intensity of the solar hydrogen Lyman alpha line; temperatures of the satellite's surface and interior; meteoric erosion, flux, and penetration; geographical, temporal, and altitudinal variations of primary cosmic ray intensity; total magnetic field at altitudes above the more densely ionized regions of the upper atmosphere; air drag; the geographical distribution of the energy received by and radiated from the earth; and the changing patterns of the cloud cover of the earth.

The satellites will be located and data will be obtained from them by means of radio, precision camera, and visual observations. The precision radio tracking system is known as Minitrack; it was developed by and is operated under the supervision of the Naval Research Laboratory. There are ten Minitrack stations, most of them along the 75th meridian West.

The 12 precision optical tracking stations, using Baker-Nunn Schmidt-type cameras, are under the supervision of the Smithsonian Astrophysical Observatory. They are located in one longitudinal and two latitudinal belts (75th meridian West and 30° to 40° North and South).

There are three programs based on amateur participation in satellite tracking which are designed to supplement precision tracking efforts. The first, for volunteer visual observation teams, is being administered by the Smithsonian Astrophysical Observatory and has been named Moonwatch. Over one hundred Moonwatch teams, located both in the United States and abroad, have been registered and are in operation.

A similar program, called Moonbeam, has also been established to coordinate the participation of radio amateurs and other volunteer groups having the capability to record telemetry and radio position data. Employing Minitrack II, developed by the Naval Research Laboratory, and Microlock, developed by the Jet Propulsion Laboratory of California Institute of Technology, these volunteer groups supplement the primary Minitrack stations in tracking the satellite and should also provide valuable scientific data.

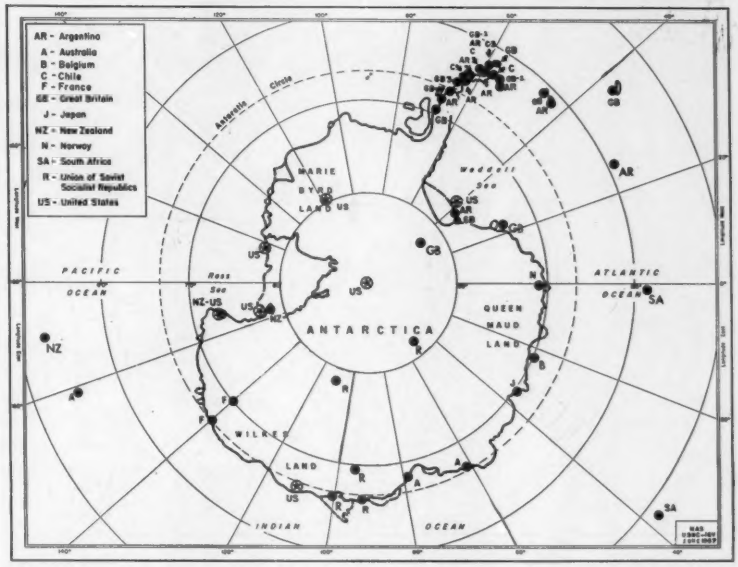
The third volunteer tracking program is called Phototrack; it was organized under the supervision of the Society of Photographic Scientists and Engineers. Participants in this program use standard cameras of good quality to photograph the satellite against a fixed background of stars of known positions.

Earth's Heat and Water Regimen

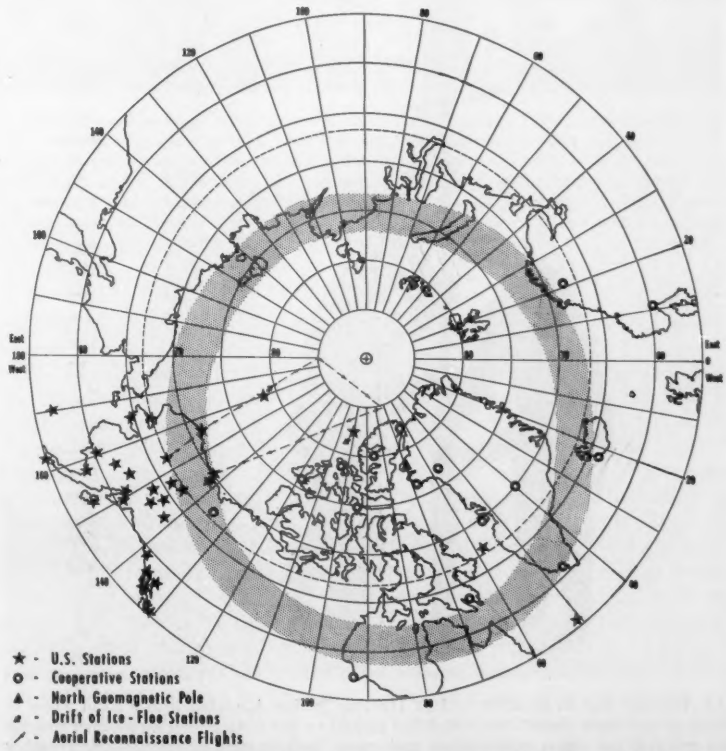
Meteorology. Almost all of the energy that the earth receives comes from the sun. This energy evaporates water from the oceans, lakes, and rivers; heats the ground, which in turn heats the air above it; and in general supplies all the energy which drives the winds of the atmosphere.

In the equatorial regions there is more energy received from the sun than is lost back to space; in the polar regions the reverse is true. Since we know that, on the average, considering a year's time, the earth as a whole does not heat up or cool off appreciably, the excess energy gained in the tropics must be balanced by the loss of energy in the polar regions. The flow of energy between the tropics and the poles is part of the driving force of the atmospheric circulation. A very important factor in the general circulation also is the rotation of the earth. As is well known, the speed at the surface, due to the daily rotation of the earth, is greatest at the equator, which is farthest away from the axis of rotation, and least in the polar regions, becoming zero at the pole itself.

In order to study the winds and circulation of the atmosphere during the IGY, meteorologists of nearly every participating country have intensified their efforts at setting up new stations in hitherto uncovered areas and are making every attempt to send meteorological balloons as high into the atmosphere as possible to measure temperature, humidity, and winds; all countries are collecting meteorological data. In cooperation with the Canadian Weather Bureau, the



IGY stations in Antarctica for the International Geophysical Year. [National Academy of Sciences]



Features of the IGY program in the Arctic region. [National Academy of Sciences]

U.S. Weather Bureau is operating some key stations in the Far North, supplementing its complex of stations in Alaska and the United States. In cooperation with scientists and weather bureaus of the various South American countries, five new complete weather observatories are now in operation in Chile, Peru, and Ecuador. These five stations are important in a chain of stations reaching from the North Pole, where the U.S.S.R. maintains a station, through Canada, eastern United States, the Caribbean Sea, western South America through Antarctica, and finally to the South Pole, where United States scientists have established a complete scientific observatory.

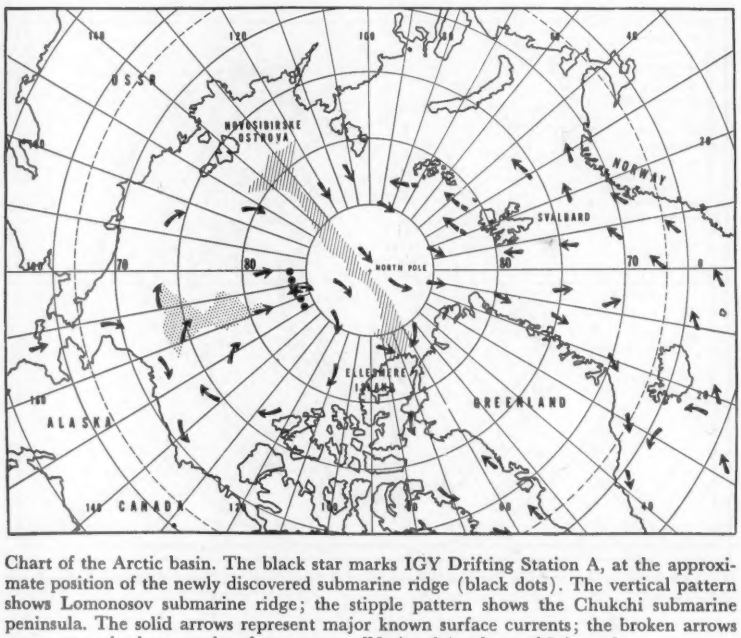


Chart of the Arctic basin. The black star marks IGY Drifting Station A, at the approximate position of the newly discovered submarine ridge (black dots). The vertical pattern shows Lomonosov submarine ridge; the stipple pattern shows the Chukchi submarine peninsula. The solid arrows represent major known surface currents; the broken arrows represent major known subsurface currents. [National Academy of Sciences]

U.S. Weather Bureau scientists at IGY Drifting Station A, coring with a hand auger to drain off the "melt water"—ice which has melted on the surface. During summer months this melting ice makes construction and camp maintenance difficult. [U.S. Weather Bureau]

In addition to this chain of stations, 12 nations have cooperated in locating more than 50 scientific observatories in the vast unknown continent of Antarctica. For the first time, synoptic meteorological charts of this area are being drawn on a daily basis. Weather forecasting has already been markedly improved in the Southern Hemisphere. Aside from the forecasting and synoptic aspect, the scientific value of the observations in Antarctica are potentially of great value in understanding the atmospheric circulation and its relation to solar radiation and topography.

The Antarctic is the coldest place on earth. The continent itself is elevated and mountainous, the South Pole being almost 10,000 feet above sea level. Byrd Station, in the interior, has reported temperatures of about 100 degrees below zero (Fahrenheit), and recently the South Pole Station reported an even lower temperature, 102.1 degrees below zero.

In the Antarctic meteorology program, large neoprene balloons have been sent to altitudes of over 80,000 feet, and the average is about 60,000 feet. Meteorological balloons sent up at 112 non-Antarctic United States stations are reaching altitudes ranging from 85,000 to 107,000 feet, carrying instruments to radio back to the ground the temperature and humidity.

In addition to these broad-scale programs, several specialized programs are under way, and preliminary results have been received. For example, there is in Little America an instrument which measures the minute quantity of ozone in the air at the ground level. Ozone mainly occurs in a layerlike region about 15 miles high in the earth's atmosphere. Some ozone diffuses to the ground or is formed at lower levels by ultraviolet light. It has been noticed that, at Little America, there is about 25 percent more ozone at the ground than there is in New Mexico. Although ozone is a minor constituent of the atmosphere, it is thought to play an important role in the circulation of the high atmosphere, because of the energy it can absorb and release.

Another minor constituent of the atmosphere which may play a major role in climatic changes is carbon dioxide. This compound is present in the atmosphere in amounts of about 350 parts per

million. It absorbs infrared or heat radiation and may act like a trap for such radiation, much as glass does in a greenhouse, and it may play a very important role in the heat balance of the atmosphere. Our industrial civilization burns tremendous quantities of fossil fuel each year, pouring millions of tons of carbon dioxide into the atmosphere. Most of this is absorbed by plant life and by the waters of the oceans, but there is the possibility that eventually the carbon dioxide content of the atmosphere will rise enough to affect the world's climate. At United States stations and aboard ships, there are seven instruments in use monitoring the content of carbon dioxide in the atmosphere, and scientists are collecting thousands of air samples for later analysis. It has been found already that the concentration of carbon dioxide in the Antarctic is about what it is over the rest of the world away from immediate industrial contamination.

The United States National Committee for the International Geophysical Year was designated by the Comité Spécial de l'Année Géophysique to establish and maintain a Weather Central at the Little America Station to collect and disseminate Southern Hemisphere weather information, particularly for the Antarctic region. The basic program at Weather Central involves the reception and recording of weather data from many contributing sources; preparation and analysis of meteorological charts, maps, graphs, and cross sections—mostly synoptic; and broadcasting of current weather information and analyses for use in forecasting by stations throughout Antarctica and the remainder of the Southern Hemisphere.

The Weather Central staff consists of United States meteorologists together with meteorologists assigned, in turn, by other nations participating in the Antarctic program.

Preliminary reports indicate that significant improvements in the weather forecasts of Southern Hemisphere countries have been made since data from the Antarctic Weather Central became available.

Glaciology. United States glaciologists are encamped on glaciers and ice fields in Greenland, on the frozen Arctic Ocean, in the mountains of Alaska, on a small glacier in the state of Washington, and on the ice shelves and the great ice sheet of Antarctica, in a broad program designed to map not only the extent of the glaciers and ice but also to understand their flow and their relation to and effect on the local climate. Twenty-seven other countries are also making observations covering all the known ice areas of the world, including glaciers on the equator —at Mount Kilimanjaro and Mount Kenya in eastern Africa.

Oceanographers lowering coring apparatus from the side of the *Vema*, an oceanographic research vessel operated by the Lamont Geological Observatory. The coring device is designed to take samples of the bottom sediment. It is a metal tube, 30 to 60 feet long and about 2 inches in diameter, which is lowered vertically, with a heavy weight on the top. When it is about one hundred feet from the bottom, a small trigger weight releases the weighted pipe, which then sinks into the bottom. The core is then withdrawn and hoisted to the ship. [Lamont Geological Observatory]

Technical advances and discoveries have already been made in the two greatest reservoirs of ice in the world, Greenland and Antarctica. In Greenland, scientists of the U.S. Army's Snow Ice and Permafrost Research Establishment have perfected techniques for drilling deep holes in the ice with hollow drills, much as an oil well is drilled, to obtain a "core" of ice. The first hole was drilled in Greenland in 1956 and reached a depth of over 1000 feet. The second hole was successfully drilled in 1957 in Greenland, and a similar operation is now under way in the Antarctic in Marie Byrd Land.

The recent boring in the ice of Greenland reached a depth of 1438 feet. A complete series of cores 4 inches in diameter were obtained from the first 1040 feet. Below this depth, recovery of the core is difficult because the release of strains as the ice is drilled causes the ice to shatter. Dissolved gas, which is under great pressure in the ice at these depths, also causes trouble because it bursts through pockets in the ice, increasing the amount of shattering. However, a core was obtained from 1200 to 1220 feet, and another from 1320 to 1338 feet. These cores are being studied with great care in the laboratory, for they are an invaluable index of climate and precipi-

Rev. Daniel Linehan, using the 45-channel seismic recorder at Cape Roydes, McMurdo Sound, Antarctica. [D. Linehan, S. J. Weston Observatory]

tation over the past many hundreds of years. Their layers are studied in much the same fashion as tree rings are studied. From the first hole in Greenland, the 1912 layer was identified by the ash from a volcano which erupted in Alaska. The dust from the great explosion in 1883 of the volcano Krakatoa, in the East Indies, will be a help in checking the dating of the annual layers of precipitation in the cores. Because precipitation is lower in the Antarctic than in Greenland, it is expected that this ash layer will be found at a depth of about 150 feet in Greenland and at about 60 feet in the Antarctic.

The great ice sheet of the Antarctic, over 6 million square miles in extent, cannot be studied in anything but a spotty fashion. However, teams of glaciologists, seismologists, and support personnel are traveling by tractors and special over-snow vehicles thousands of miles across the ice in a series of traverses to obtain the profile of ice thickness across the continent and to attempt to learn something of the underlying terrain, or formation of the ice-covered earth. For example, after the Byrd Station was established some 600 miles from Little America by a tractor party, a traverse team then crossed the ice shelf from Little America and continued to Byrd Station, exploring the ice as it went.

The surface ice is examined by taking samples and determining the density, digging shallow pits to learn about the layers of the most recent several seasons, and making measurements of the temperature and heat conductivity of the ice. The deep ice is explored by setting off small explosions on the surface and by listening to echoes reflected by the bottom of the ice and by any deeper layers of the earth's crust. The time the echoes take to return allows calculation of the depth of the ice.

During this first traverse it was discovered that Byrd Station, at an elevation of about 5000 feet above sea level, stands upon ice almost 10,000 feet thick. Further explorations will reveal whether this is a frozen fjord or inland sea and what part of this submergence may be due to the bending inward of the earth's crust as a result of the weight of the ice.

United States scientists at two locations in the Arctic basin are now making studies of the melting of the ice pack, the freezing of new ice, and the general relations between the state of the ice and the local climate. One of these stations, Drifting Station B, is on an "ice island" 7 miles by 3 miles in extent and about 140 feet thick. This block of ice was probably calved off the Ellesmere Island ice sheet many hundreds of years ago and has been circulating in the Arctic Ocean since, driven by the winds and ocean currents. This ice island, known as Fletcher's Ice Island, has been occupied previously by United States scientists in studies of the Arctic basin. It is currently at latitude 81°08′N and longitude 107°05′W, about 611.8 miles from the North Pole.

The second station, called Drifting Station A, is now located at latitude 85.30′N and longitude 170°W, 310.5 miles from the Pole. It is on the ice pack itself, on a floe a few square miles in area and only some 7 to 12 feet thick. Scientists there have noted that, during the past summer season, about 12 inches of ice on the upper surface has melted, while as much as 18 to 24 inches of new ice has frozen on the bottom of the floe. This observation will be placed in proper perspective when all the information on radiation from the sun, ocean currents, and temperatures of the air, ice, and oceans has been studied.

Oceanography. The oceans, which cover about three-quarters of the earth, are a great storage trap for energy; the oceans are responsible for the fact that the climate of lands near seacoasts is more uniform than that of the interior of continents. Great ocean currents such as the Gulf Stream affect climates in the northern parts of the Atlantic Ocean. For example, Iceland and the British Isles have far less severe winters than they would have were the Gulf Stream not flowing. The surface currents of the oceans are related to the great wind systems, and it has been shown that the Gulf Stream, for example, follows the great clockwise atmospheric circulation in the Atlantic basin. Benjamin Franklin was one of the first to observe the nature of the Gulf Stream; Lieutenant M. F. Maury, the founder of the U.S. Navy Hydrographic Office, collected much information from mariners bearing

on the set and speed of surface currents in this area, and several years ago an expedition of several ships, Operation Cabot, explored the Gulf Stream in a thorough fashion. It was found that, besides the main stream, there were many small eddies and side currents.

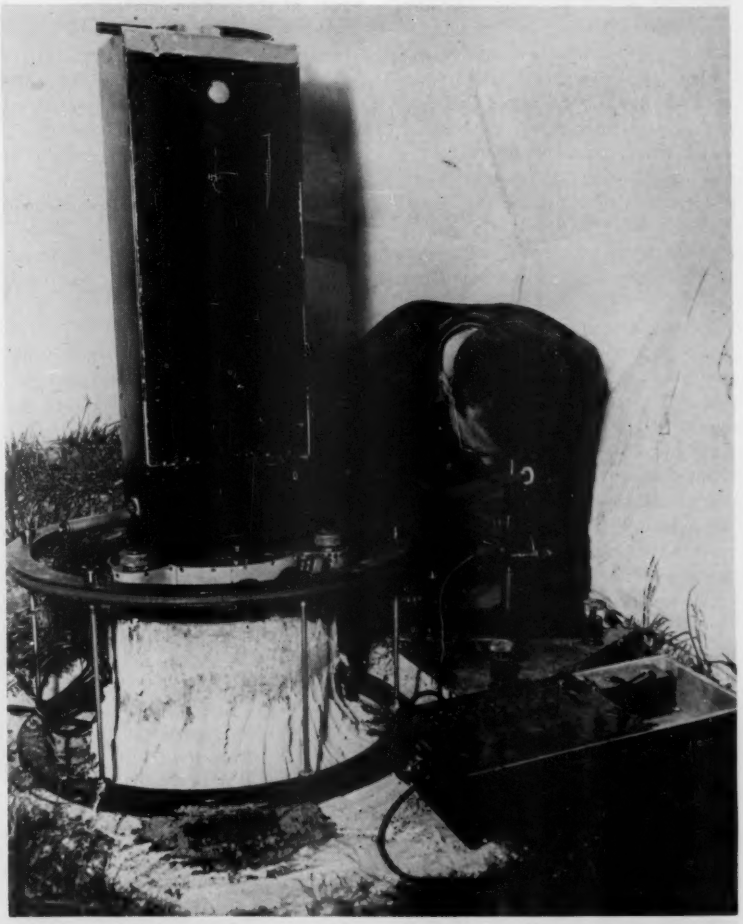
Recently, in a test of instrumentation developed by J. C. Swallow of the National Institute of Oceanography in England, the *Atlantis*, a research vessel of the Woods Hole Oceanographic Institution, and the British research vessel, *Discovery II*, explored the eastern edge of the Gulf Stream and were able to map for the first time the underlying flow of water. They found that, at depths of about 6500 feet, there was either very little or very erratic movement; shallower depths showed set to the northeast, as expected, but at depths of about 9000 feet, the current sets southwest at the relatively high speed of 8 miles per day. This new technique, in which the Swallow neutral buoyancy float is used, enables IGY oceanographers the world over to map both surface and relatively deep currents. Thirty-four countries are participating in oceanographic work for the IGY, some with ships and others with coastal and island observatories.

The deeper currents of the oceans have proved difficult to observe. Cold water is formed in the polar regions from melting ice; this water, being dense, sinks, displacing lighter water which then flows away from the polar regions towards the equatorial regions. Bottom topography such as ridges, canyons, and mountain ranges influences the flow of bottom waters, and it is possible that some bottom waters become trapped in basins. It is not known whether bottom water makes a circuit from pole to equator and back in tens, hundreds, or thousands of years. The bottom waters play an important role in man's economy, for the extent to which the seas can support life is dependent upon the food supply in the water. The bottom waters are rich in chemical nutrients, and, wherever these waters upwell, there are found the great fishing banks, such as the Grand Banks off Newfoundland and the Peruvian fishing grounds.

Several United States ships have already made extensive cruises for the IGY. The work of the *Atlantis* has already been mentioned. The *Crawford*, also of the Woods Hole Oceanographic Institution, made a four months' cruise in the Atlantic. The *Crawford* reoccupied many stations taken years ago by the German ship *Meteor* and discovered that there have been pronounced changes in the amount of oxygen dissolved in the Atlantic in the region of 15° south latitude. The difference in oxygen content over the past 30 years may mean that deep bottom water is not being formed as fast now as it was previously, but further data and analysis are needed for proper interpretation of the present observations.

The *Vema*, a research vessel operated by the Lamont Geological Observatory of Columbia University, has completed an extensive cruise in the South Atlantic Ocean, working along the coasts of South America and Africa, and crossing the Atlantic at high southern latitudes between Argentina and Capetown. The *Vema* cooperated with the *Bahia Blanca*, a survey vessel of Argentina, in making explorations of the submarine crust by seismic methods. Considerable marine biological work was also done, and Lamont has reported that living organisms —a small shellfish and a worm one-fourth of an inch long—were recovered alive from depths of 13,200 and 16,200 feet, respectively. Lamont scientists believe these to be record depths for retrievement of live marine samples. The *Vema* left New York in November for a ten-month trip to the Atlantic and Indian oceans as the second phase of Lamont's oceanographic work for the IGY.

In the Pacific, the *Brown Bear* of the University of Washington worked in the Northeast Pacific Ocean last summer. The deep currents in that area were studied. The *Horizon* and *Baird*, research vessels operated by the Scripps Institution of Oceanography of the University of California, left San Diego in October for a two-ship, five-month expedition through the Central and Southeast Pa-



Scientist reading an interferometer to measure the alignment of pendulum support in determining the value of gravity. [U.S. Coast and Geodetic Survey]

cific. They will call at Tahiti (Samoa), Easter Island, Valparaiso (Chile), and Callao (Peru) and make seismic explorations of the submarine crust, study surface and deep currents, take bottom samples, and occupy about 40 oceanographic stations, where water samples down to great depths will be obtained for later analysis of chemical content. The *Jakkula,* of the Agricultural and Mechanical College of Texas, will cruise in the Caribbean Sea and western Atlantic in the summer of 1958.

Another part of the IGY oceanography program is the study of the mean sea level over the period of the IGY. It has been found from study of tide data that there seems to be an exchange of water between the Northern and Southern Hemispheres as the seasons change. Some of the change in mean sea level between summer and winter has to do with the expansion and contraction of water with temperature. New tide gauges are being set up to supplement the existing network: instruments are already operating in Bermuda, Iceland, and the Azores, in the Atlantic, and in the Caroline and Marshall islands and, with the cooperation of French scientists, at French islands in the Southeast Pacific. A station is in operation on Pitcairn Island under the supervision of a descendant of one of the mutineers of *H.M.S. Bounty.* At least 200 tide gauge stations are being operated in the worldwide program, 32 of them by the United States.

In the Arctic basin, United States oceanographers pursue their science from camps on the frozen ocean. The track of one of the stations has carried observers over what appears to be a newly-discovered ridge, or underwater mountain chain. Scientists of the Soviet Union are doing similar work at two stations in the Arctic basin.

In the Antarctic the ships of the various nations supporting scientific stations on the continent engage in oceanographic observations en route to and from the area. Thus, U.S.S.R. and New Zealand ships have added to our knowledge of these waters. Ships of U.S. Navy Task Force 43 are also exploring the coast, charting the bottom, and taking bottom and water samples for future study.

Earth's Structure and Interior

Seismology. During the IGY, seismologists of 50 nations are obtaining earthquake information from almost all regions of the world, particularly in those regions not hitherto covered, as, for example, the Antarctic continent. In addition, several new types of seismographs with wide range and high sensitivity have been located at observatories throughout the world. The Lamont Geological Observatory has constructed ten special, long-period seismographs and has installed most of them at observatories ranging from Hawaii to Fiji and from Bermuda to the Antarctic. These long-period instruments are sensitive to surface waves with periods of about 400 seconds, generated only by the very largest earthquakes. These wavelengths are so long that they penetrate to the interior of the earth, and, in fact, the whole earth itself may be set into vibration. Recently workers at Lamont have discovered the existence of certain intermediate waves with periods of about 100 seconds. These waves, which were previously only known in the crust in continental structures, have been identified now in the mantle, or the next layer beneath the crust. These waves permit better resolution of structural details than the longer 400-second waves, and study of their propagation is expected to provide new information on the distribution of materials in the interior of the earth.

Seismologists from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington worked on exploration of the roots of the Andes Mountains in South America last summer and fall. They have found roots of unsuspected depths and are now working on their data to obtain better understanding of the crustal structure under this great mountain chain.

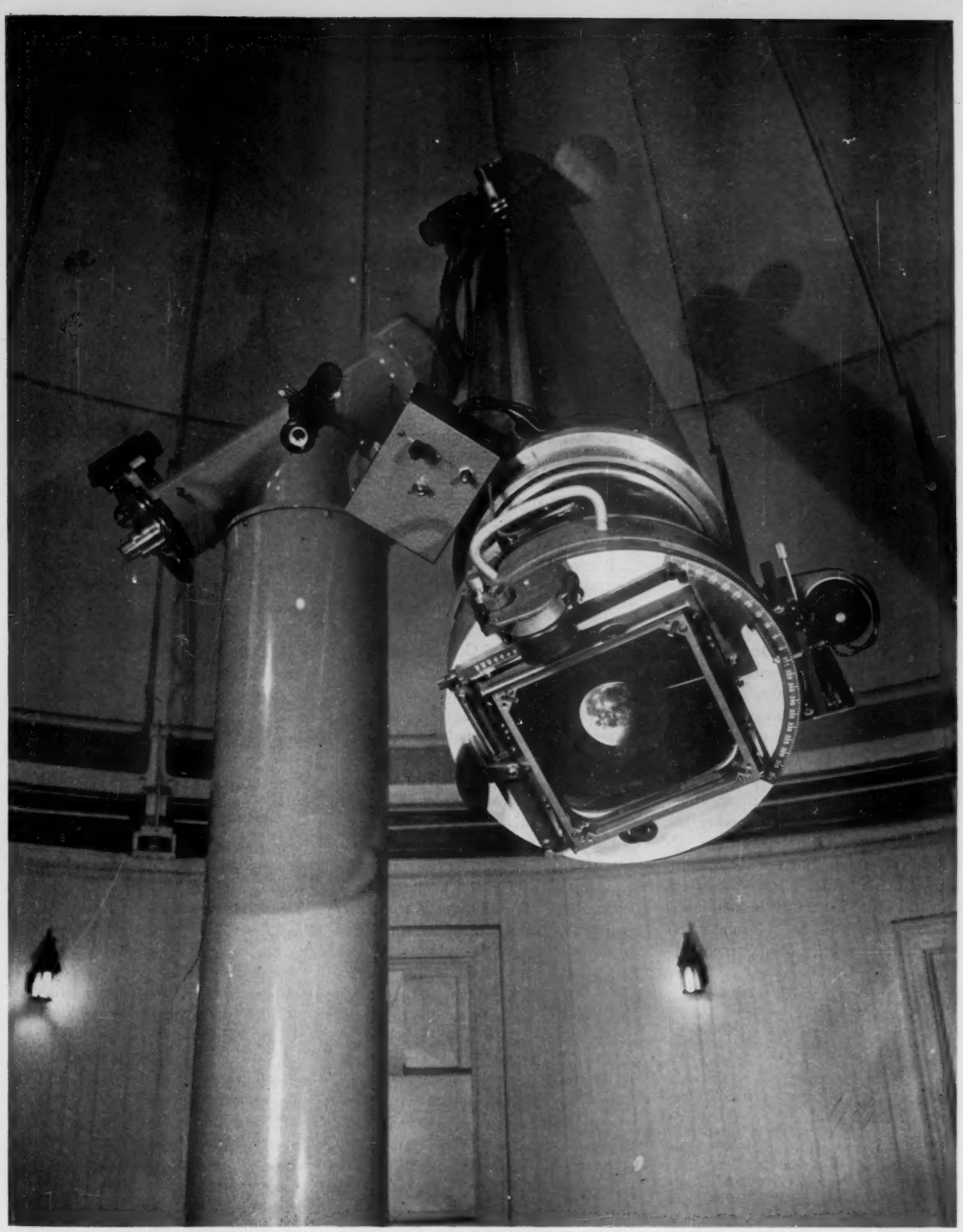
Seismologists of the U.S. Coast and Geodetic Survey have installed new seismic equipment in the Pacific at Truk and Koror and have been obtaining records of Pacific earthquakes. These new stations, together with those in the Antarctic, will add significantly to our knowledge of seismicity and the structure of the earth.

Gravity. The earth is the attracting mass for all bodies on the earth. The earth, however, is not a perfect sphere, nor is its mass uniformly distributed. Furthermore, it is rotating. These conditions add up to the fact that gravity is not uniform and constant all over the earth. In general, because of the fact that the earth bulges somewhat at the equator and centrifugal force is greatest there, gravity is least at the equator and increases toward the poles. This effect is large enough to make a 200-pound man weigh one pound more at the pole than at the equator. In addition to this nonuniformity, great continental mountain masses, underground ore bodies, undersea mountains, and, in general, the uneven distribution of mass around the crust of the earth, contribute to "local anomalies," some of which may be sufficiently large to deflect a plumb bob away from the vertical. Although this deflection is less than ten seconds of arc, there are a few locations—Puerto Rico is one—where it exceeds one minute. This effect is significant in geodesy wherever geodetic control depends on astronomical observations.

The IGY program in gravity is aimed at increasing the reliability of measurements of gravity over the world, particularly in providing very accurate and reliable measurements at certain key locations to provide connection points between the gravity networks of various countries. Many measurements have been made already, including observations in the Arctic basin taken from United States IGY stations on the drifting ice. An important new station is located in Antarctica, where first-order measurement of gravity was made to provide a calibration for future measurements in the interior.

The first successful surface measurements of gravity on the open sea were made on 22 November 1957, by J. Lamar Worzel of the Lamont Geological Observatory, who used a sea gravimeter developed by Anton Graf of Munich. In the past, gravity measurements for oceanic areas required measurements aboard submarines at quiet depths below the surface. The difficulty of obtaining and fitting submarines for this purpose made it impossible adequately to survey the seas: only about 4000 such measurements have been made throughout the world. The new instrument, mounted on a gyro-stabilized platform, will make it possible to obtain data simply and quickly anywhere at sea with a precision of one part per million, similar to that attainable on land.

As the moon rotates around the earth and the earth rotates around the sun, the solid earth undergoes the same kind of tidal bulging that occurs in the oceans, although, of course, by a much lesser amount. Yet, it is enough to be observed with the most sensitive gravimeters. As the earth heaves in tidal motion, the distance of a point on the surface from the center of the earth changes by a small amount, perhaps a few tenths of an inch



Dual-rate moon position camera and telescope. Composite photograph shows how the moon appears through the dark filter at the center. The camera photographs the moon and surrounding stars simultaneously. The position of the moon is held fixed with respect to the stars during the exposure by means of a dark filter which tilts. The photographs obtained make it possible to determine the position of the moon accurately, and from this, precise determination of latitudes and longitudes can be made, completely free of the distortion of gravity. The camera was developed by William Markowitz of the U.S. Naval Observatory. Twenty cameras have been provided to observatories scattered around the world. [National Academy of Sciences]

to several inches. This can be detected directly by instruments which are now in use recording the "pulse" of the earth, instruments which are sensitive to one part in one billion of the average value of gravity.

Latitudes and longitudes. Scientists of 29 countries at 45 IGY stations around the world are in the process of determining longitudes and latitudes more precisely. Besides making transit observations at three stations, the United States is furnishing 21 of the moon position cameras developed at the Naval Observatory for use at stations in the United States and throughout the world; the first camera is now in operation at the U.S. Naval Observatory in Washington, D.C. When used in conjunction with the Danjon impersonal astrolabe, this instrument will permit more precise location of the earth's land masses than was hitherto possible.

IGY Data

The preceding sections suggest the nature of the IGY activities as shown by the United States IGY effort in the first few months of the program. With 67 nations cooperating in the endeavor and some 10,000 scientists and technicians making observations and measurements at more than 2000 stations, the volume of data stemming from the program will be considerable. To ensure the safety of the raw data and their accessibility, the international IGY committee has approved the establishment of three world data centers.

World Data Center A is located in the United States and has 11 subcenters: visual auroral observations (Cornell University); instrumental auroral observations (University of Alaska); airglow and ionospheric physics (National Bureau of Standards, Central Radio Propagation Laboratory); cosmic rays (University of Minnesota); geomagnetism, gravity, and seismology (U.S. Coast and Geodetic Survey); glaciology (American Geographical Society); latitude and longitude (U.S. Naval Observatory); meteorology (U.S. Weather Bureau, National Weather Records Center); oceanography (Agricultural and Mechanical College of Texas); solar activity (University of Colorado, High Altitude Observatory); and rockets and satellites (National Academy of Sciences).

World Data Center B, operated by the U.S.S.R., has two subcenters. The first, at Novosibirsk, includes meteorology, geomagnetism, longitude and latitude, glaciology, oceanography, seismology, and gravity. The second, at Moscow, includes aurora and airglow, ionospheric physics, solar activity, and cosmic rays.

World Data Center C, operated by several nations in western Europe and the Pacific, has the following subcenters: geomagnetism (Denmark and Japan), aurora (Sweden and Great Britain), airglow (France and Japan), ionosphere (Great Britain and Japan), solar activity (Switzerland, Italy, Great Britain, France, German Federal Republic, and Australia), cosmic rays (Sweden and Japan), glaciology (Great Britain), meteorology (World Meteorological Organization, Geneva), and seismology (International Central Seismological Bureau, Strassburg).

Each data center will acquire a complete set of all IGY data. Each center will archive and index its compilation of data, holding it accessible to research workers. Schedules for the orderly flow of data into the centers have been arranged. These schedules vary, depending upon the nature of the data in a given discipline and upon the definition of a reasonable "lot" of data to simplify the handling problems. A "lot" of data may be one month's observations in one field or several months' observations in another.

The procedures in handling data and forwarding them appropriately involve a series of steps of the following kind: (i) collection of a "lot" of data at a field station, (ii) transmittal of the "lot" to the home laboratory of the field station, (iii) checking of field data at the home laboratory, (iv) transmittal to one of the world data centers, (v) copying of the data by one world data center for the other two and appropriate transmittal, and (vi) indexing and archiving at world data centers.

The data centers are in operation, and data are flowing into the centers. The steps outlined above lead to a peak early in 1958 and a steady 18-month plateau through at least the first six months of 1959, followed by a "clean-up" period extending probably into the first quarter or so of 1960 (*1*).

Note

1. The preparation of this narrative would not have been possible without the cooperation of many scientists and institutions engaged in the IGY program. Although some of them are mentioned in the text, it has not been possible in this summary to refer to all. The United States IGY program has only been possible because so many individual scientists as well as public and private institutions have participated and cooperated in the endeavor. Particular acknowledgment is made to members of the National Academy of Sciences' IGY staff who have helped in the preparation of this report: Stanley Ruttenberg, Phillip Mange, John Hanessian, Jr., and John Truesdale.

Groningen Radiocarbon Dates II

H. de Vries, G. W. Barendsen, H. T. Waterbolk

The first series of radiocarbon dates obtained at the University of Groningen has been published previously (*1*). This list (*2*) covers the measurements made during the period from August 1954 to March 1956. During part of this period, three counters were in operation, and in the course of time various improvements were introduced. These resulted in a simplification of the chemical procedure and in a reduction of the background (*3–6*).

The present characteristics of the counters can be summarized as follows. The counters are normally filled with carbon dioxide at a pressure of 3 atmospheres. The first counter has a background of 2.4 counts per minute and a net recent carbon count of 5.64 per minute. For the second counter, the corresponding figures are 0.91 and 14.6 counts per minute. The large counter, finally, has a background of 2.4 counts per minute and a recent carbon count of 37.0 per minute. The variation of its background per centimeter change in barometric pressure is 0.05 count per minute. The samples numbered between 500 and 600 were measured in this counter. The samples numbered above 900 were measured in the second counter, whereas the samples numbered below 500 and between 600 and 900 were measured in the small counter.

Various pretreatments for the samples were used (*7*). As a rule, the samples reported in this article were given the following pretreatment. Peat was washed only with hot, diluted hydrochloric acid in order to remove carbonates, if present. Charred material was boiled first with hydrochloric acid, then with sodium hydroxide (5 percent) in order to remove humic acids, and finally washed again at a *p*H below 5. Since the charred wood is never completely elementary carbon, often less than half of the initial amount of material is left. Consequently, this treatment was not applied in cases where only a small amount of material was available. In a few cases the various fractions of the samples were dated separately, and generally the difference between the fractions was not significant. Wood was always boiled with hydrochloric acid, and sometimes it was given the same treatment as charred material.

The errors given are the standard deviations (σ) as calculated from the statistics of the counted particles. It was checked that the fluctuations did not exceed the normal fluctuations. The contributions of the background and of the calibration sample of recent carbon to the final statistical error are also included, though they are very small and are not of interest for a comparison of data obtained by the same counter. Our error does not include the possible error in the half-life of carbon-14 (5570 years). We have used a number of calibration samples of recent carbon which did not give a significant difference. Because of the combustion of fossil oil and coal, the activity of these samples may have been too low ("Suess effect"). All the ages given may therefore be too low, but a correction will be applied as soon as all stations have agreed on its value. A preliminary measurement on charred wheat from 1648 gave a correction of about 250 years. This large effect was not due to isotopic fractionation since the C^{12}/C^{13} ratio was identical for this sample and for our recent calibration sample. Finally, the possible error introduced by isotopic fractionation by the plant (or animal) has not been taken into account. For a few samples this fractionation has been determined by measuring the C^{12}/C^{13} ratio.

A large number of samples pertaining to the problem of the lowering of the Dutch coast relative to sea level were dated. These samples provided a very complex set of data (*8*). Another group of samples related to geological problems of the Gulf of Paria (see our first dating results, *1*) is still being studied.

The remaining dates are given here in three groups (Tables 1–3). The first group contains some individual samples related to special geologic problems. The second group consists of a series of geologic samples from northwestern Europe, ranging in age from about 50,000 years ago to the present. This group includes some standard sections and datings of pollen zones. The third group deals with archeological samples from Europe, Africa, and America. As far as possible, the samples have been arranged in chronological order. Descriptions of the samples and short comments on the dates have been provided by those who were responsible for collecting the samples.

For the sake of clearness one of us (H.T.W.) standardized descriptions and comments to some extent. Wherever possible, related samples have been commented upon jointly. Unless explicitly mentioned, nothing has been added to the conclusions arrived at by the scientists responsible.

Table 1. Geological samples (special problems). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
Demarara (British Guiana). Charcoal from Demarara. Expected age, Tertiary (*9*).	Gro-416 Gro-501	> 29,000 > 50,000
Onverdacht (Surinam). Charcoal encountered in laminated bauxite at Onverdacht, Surinam. The quantity available was small. Since the sea level must have been considerably lower during the time when the bauxite was formed, a Pleistocene age was considered probable. These samples were collected and submitted by J. F. van Kersen, Geologisch Instituut, Leiden. For further details see Van Kersen's thesis (*9*).	Gro-371	> 10,000

Dr. de Vries is professor of biophysics at the Physical Laboratory, University of Groningen, Groningen, Netherlands. Dr. Barendsen is a physicist at the Radiobiological Institute of the National Health Research Council, Rijswijk, Netherlands. Dr. Waterbolk is professor of prehistory at the Biological-Archeological Institute, University of Groningen.

Table 2. Radiocarbon dates obtained on geologic samples, including samples from pollen zones (from "standard profiles"). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
I. *Pleistocene.*		
De Voorst. Five samples from a well-exposed profile near De Voorst in Northeastern Polder, previously Zuiderzee, which is commonly considered as typical for the lower part of the Eemian interglacial (Jessen and Milthers' zones b, c, d, and e). A new pollen diagram of the site has been prepared by W. van Zeist, Biological Archeological Institute, Groningen. These samples have been measured in the large counter several times in the course of 2 years. The results of the first series were the same as the results obtained with the improved apparatus, with its lower background and barometric effect. We therefore give only the average results, together with our station number of the last measurement made on each sample. Depths below sample XI are given; activities are given in counts per minute.		
Sample XI: peat; depth, 0 cm; activity, 0.27 ± 0.03.	Gro-564	39,480 ± 800
Sample XIa: peat; depth, 0 cm; activity, 0.133 ± 0.02.	Gro-597	45,200 ± 1300
Sample II: peat; depth, 18 cm; activity, 0.26 ± 0.03.	Gro-567	39,790 ± 800
Sample VIII: peat; depth, 75 cm; activity, 0.13 ± 0.015.	Gro-1210	45,360 ± 1000
Sample VIIIa: peat; depth, 75 cm; activity, 0.10 ± 0.02.	Gro-1209	47,470 ± 1500
Sample IX: wood; depth, 85 cm; activity, 0.01 ± 0.02.	Gro-1201	> 57,000
Sample IX corresponds to the earliest phase of the Eem, lying nearly on the boulder clay; it represents the climatic optimum. The upper layers, about 15 cm above sample XI, were partly eroded off, probably during the formation of the Zuiderzee, and partly removed by a machine that dug a canal through this area of Eemian peat (*10*). Sample numbers marked *a* indicate that the sample was given a thorough washing with HCl and NaOH solution. For the upper layer (XI), this gave a pronounced decrease of activity, indicating that recent material had infiltrated, for recent material may be washed out more readily than original material. This effect is appreciable for the upper sample. For sample VIII it is not significant. This would be expected from the fact that the sample was well preserved. The sample consisted of *Hypnum* peat, which was still unoxidized (yellow) when excavated. Samples II and XI were more sandy and thus could have been more readily infiltrated, though they were still very compact and heavily compressed. The result, at least for sample VIII, seemed to be reliable. Nevertheless, the recent measurement of Eem samples from the type locality, which is protected by a layer of at least 8 meters of sand, gave a very high age even for the upper layers of the Eem. Something therefore has been wrong with the preservation of the samples described above; this presents a good example of the difficulties involved in the dating of very old layers. Collected by F. Florschütz, A. J. Wiggers and two of us (H. T. W. and H. de V.).		
Northeastern Polder (former Zuiderzee). Pure *Hypnum* peat, situated between loamy coversand and fluviatile sediments at a depth of 8.00 to 8.20 m near Emmeloord (*11*, p. 30, Figs. 1, 9). According to the pollen diagram by Florschütz, the age would be pleniglacial (more than 90 percent nonarboreal pollen). Collected and submitted by A. J. Wiggers, Dienst Noord-Oostpolderwerken, Kampen.	Gro-390	29,000 ± 5000
Wouw (province of Noord Brabant, Netherlands). Lower part of peat layer at a depth of 90 to 120 cm (sample 110 to 120 cm) near farm "De Grote Plas," municipality of Wouw. The peat is overlain by loamy sand and rather coarse sand. The pollen diagram by Florschütz shows 90 percent nonarboreal pollen, which would suggest a pleniglacial age. The peat, however, contains remains of *Carex*. Collected and submitted by L. van Dorsser, Geographical Institute, Utrecht.	Gro-931	28,500 ± 540
Breda (province of Noord Brabant). Peat layer in the Ganzeweide, municipality of Breda. Alternating peaty and loamy layers occur at a depth 120 to 220 cm. Grain-size analyses have shown that the loam probably consists of loess mixed with sand. Below 220 cm the material mainly consists of peat. The sample was taken at a depth of 2.80 to 3.00 m. The pollen diagram points to a pleniglacial age. Sample collected and submitted by L. van Dorsser.	Gro-936	32,000 ± 900
Samples Gro-390, 931, and 936 all refer to peat of pleniglacial age (*12*) overlain by loamy coversand. Sample Gro-936 antedates a previously unknown loess sediment in the North Brabant area.		
Usselo (province of Overijsel). A new excavation of the Usselo site in 1955 by C. C. W. J. Hijszeler of the Rijksmuseum Twenthe, Enschede, made it possible to collect a series of samples especially for dating purposes. The section corresponds to Van der Hammen's profile B (*12*, p. 117; *13*). The material consisted of moss peat more or less mixed with dune sand. In view of local irregularities in the lamination—mostly due to cryoturbation—the samples were collected at three different places. These three sections could be correlated by means of a number of clearly visible key layers. The samples given below are listed in order from top to bottom. The zone indications are based on the detailed pollen diagram by Van der Hammen. The samples were taken in the presence of S. Hansen and H. Krog (Danish Geological Survey), H. T. Waterbolk and A. Bohmers (Biological-Archeological Institute, Groningen) and W. H. Zagwijn (Geological Survey, Haarlem). A few check pollen analyses of the dated samples were carried out by W. van Zeist.		
Sample BC-1: upper peat (*Pinus* phase of Alleröd).	Gro-925	11,065 ± 120
Sample BC-III: upper peat (*Betula* phase of Alleröd).	Gro-933	11,875 ± 120
	Gro-948	11,515 ± 120
		Average 11,700 ± 90

Description	Sample No.	Age
Sample BC-III: combusted again.	Gro-947	11,470 ± 90
Sample BB-II: sandy intercalation with thin *Hypnum* layers (*Betula* phase of Alleröd).	Gro-921	11,560 ± 100
Sample BA-I: lower peat (older Dryas or top of Bölling).	Gro-926	11,825 ± 120
Sample BA-III: lower peat (Bölling).	Gro-927	12,355 ± 170
Sample BA-V: lower peat (Bölling).	Gro-1104	12,300 ± 100
Sample BA-VI: thin organic layer below lower peat (oldest Dryas or beginning of Bölling).	Gro-928 Gro-935	12,200 ± 100 12,380 ± 130

A detailed discussion of the results must be postponed until full palynological data are available and the ages of more samples have been determined. It seems clear, however, that the Bölling period precedes the Alleröd period by a very short interval. The same was observed in Germany (*14*). The Alleröd dates agree with those obtained in Denmark (*15*).

Ruds Vedby (Denmark). Wood from the boundary Alleröd/Younger Dryas, dated in Copenhagen (sample K-101) to 10,890 ± 240 yr (*15*) and in Washington (sample W-82) to 10,260 ± 200 and 10,510 ± 180 yr (*16*). Submitted by H. Tauber, Copenhagen. The present result agrees with that obtained in Copenhagen; the Washington dates seem somewhat too young.	Gro-454	10,995 ± 250
Bergen op Zoom (province of Noord Brabant). Lower part of gyttja sediment in a depression east of the Zoom. Depth 1.60 m. Supposed age, Alleröd or Younger Dryas. Sample collected and submitted by L. van Dorsser. The result suggests formation in the Younger Dryas time. This date is very reasonable: the lakes were formed in the Alleröd valleys, which were locally blocked up by Younger coversand deposits.	Gro-419	10,345 ± 275
Northeastern Polder (former Zuiderzee). Two samples from a late glacial peat layer (*11*, p. 38, Fig. 13) at a depth of about 1.50 m. On the basis of a pollen analytical investigation by Florschütz, the layer would be of Alleröd (lower part) age.		
The upper sample (A-19-I) consists of clayey peat.	Gro-343	12,165 ± 350
Sample A-19-II: remeasured.	Gro-410	11,200 ± 320
The lower sample (number of submitter A-19-II) consisted of peat.	Gro-373	10,500 ± 300
Sample A-19-II: remeasured.	Gro-413	11,560 ± 260
A third sample came from a peat layer below late-glacial river loam and overlying coversand (Parcel E-155). It gives the expected age of the transition between the Alleröd and the Younger Dryas (*11*, pp. 40–42, Figs, 16, 17).	Gro-375	10,500 ± 280

These samples were submitted and collected by A. J. Wiggers. The difference between the duplicate measurement of samples A-19-I and A-19-II is somewhat larger than the statistical error. It has not been possible to explain this. The final results are according to expectation. For details see Wiggers (*11*, p. 38, Fig. 13; pp. 40–42, Figs. 16, 17).

Wychense Ven (municipality of Wychen, province of Noord Brabant). Four samples from a gyttja sediment covered by fen peat in the Wychense Ven. According to pollen analysis (Florschütz) the gyttja could either comprise older Dryas, Bölling, and Alleröd time, or belong wholly to the Younger Dryas time. The samples were collected and submitted by L. J. Pons, Stichting Bodemkartering, Bennekom.		
Sample WVD-A (2.85 to 2.90 m).	Gro-660	9255 ± 180
Sample WVD-B (2.95 to 3.00 m), light brown gyttja with many plant remains, much humus, and little clay.	Gro-625	9260 ± 185
Sample WVD-C (3.32 to 3.36 m), peaty gyttja layer with clay gyttja.	Gro-627	10,580 ± 240
Sample WVD-D (3.70 to 3.90 m), humic gyttjalike loam passing into grey loam with plant remains and black spots.	Gro-632	10,640 ± 220

The results prove that the gyttja sedimentation took place mainly in the Younger Dryas period. For further details see Pons (*17*).

Charcoal from Usselo layers. The following five samples belong to one series of charcoal samples, found in the *Usselo* layer, from different localities in the Netherlands. To this series may be added samples Gro-498, 603, and 607 in Table 3. They all refer to a thin charcoal-containing layer in coversand. In most cases this layer is clearly a part of a soil profile (Usselo layer) which is roughly contemporaneous with the Alleröd period. At the type locality, the charcoal itself could be followed by Van der Hammen (*12*) into the peat and thereby could be dated to the uppermost part of the Alleröd period. The samples from Deelen, Ugchelen, and Hilversum were collected and submitted by G. C. Maarleveld, Stichting Bodemkartering, Bennekom; those from Velzen and Lemele by H. D. M. Burck, Geologische Dienst, Haarlem.

Deelen (province of Gelderland). Charcoal from a layer below sand ridge (pseudoås) (*18*) near Deelen. Depth 2.10 m. It is supposed that the ridge dates from Younger Dryas time and the charcoal from the Alleröd time.	Gro-909	11,025 ± 120
Ugchelen (municipality of Apeldoorn, province of Gelderland). Charcoal from cryoturbate layer, depth 1.30 to 1.40 m. A peat layer overlying the charcoal layer dates according to pollen analysis from the Younger Dryas time. Two samples were taken at a short distance from one another.	Gro-907 Gro-937	10,770 ± 120 10,555 ± 130
Hilversum (province of Noord Holland). Charcoal from a layer below a sand ridge near the Craylo bridge at Hilversum. Depth 3.00 m. Expected age, Alleröd.	Gro-920	10,660 ± 90
Velzen (province of Noord Holland). Charcoal from the Usselo layer in the tunnel pit. The quantity of charcoal was so small that no NaOH treatment could be applied. Infiltrated humus might therefore be present, giving rise to a lower age.	Gro-646	10,365 ± 200
Lemele (province of Overijsel). Charcoal from the Usselo layer. Also in this case the quantity was too small for NaOH treatment.	Gro-647	11,230 ± 400

The dates so far obtained closely agree. The mean value is about 10,800 yr—that is, it falls exactly in the transitional period between Alleröd and Younger Dryas time (see above). It is tempting to see a connection between

Description	Sample No.	Age
these widespread and apparently synchronous forest fires and the declining climate. As Hijszeler recently suggested, volcanic ash from Eifel eruptions might have set the dying forest on fire (see below). It is of interest to emphasize the small scatter between the different samples. The weighted average of the ages, including the samples Gro-498, 603, and 607 mentioned above, is 10,800 yr, and the average value of the square of the deviation of individual results from this average, divided by the standard deviation given, is 1.8. If we had made repeated measurements on one sample, this average should have been 1. The difference is significant, but if sample Gro-646 is left out (this sample may have contained younger contamination) the average mentioned becomes 1.1. This means that the statistics do not exclude the same age for all our samples, especially since there should be an extra scatter due to the fact that not all the trees would have been of the same age at the moment they were set on fire.		
Schalkenmehrener Maar (Eifel, Germany). Gyttja from the East crater of the Schalkenmehrener "Doppelmaar" (Vulkaneifel), directly above tuff-sand layer from the middle of the Younger Dryas time (*19*). Depth 4.20 to 4.30 m. Expected age about 10,500 yr. Collected and submitted by H. Straka, Botanical Institute, Kiel, Germany. The second measurement has a much smaller error. It was undertaken to get a better basis for comparison with the dates of the Usselo layer (mean value, 10,800 yr). If we take into account a possible tree age of 100 to 200 yr and some 50 yr for the time of formation of 10 cm of gyttja after the tuff sedimentation, the difference does not seem to be large enough to exclude the possibility suggested above. Moreover, there were larger eruptions in the Eifel region that occurred before the eruption corresponding to the sample considered here.	Gro-458 Gro-961	10,770 ± 250 10,550 ± 100
II. *Holocene.*		
Emmen (province of Drente). Nine samples from a profile east-northeast of Emmen, in the former vast raised bog (Burtanger Moor) on the border between the Dutch province of Drente and Germany. The samples have been chosen at pollen levels which, according to earlier investigations in the same bog (*20*), have a regional value. The section was as follows: 0 to 44 cm, fresh-to-rather-fresh *Sphagnum* peat; 44 to 185 cm, highly humified *Sphagnum* peat; 185 to 252 cm, wood peat; 252 to 299 cm, fen peat; 299 to 314 cm, gyttja; 314 to 330 cm, moss peat; below 330 cm, sand. Samples collected and submitted by W. van Zeist.		
Emmen VI (−17 cm): immediately above the beginning of the first important increase of *Fagus*.	Gro-479	2600 ± 140
Emmen VII (−24 cm): immediately below the first important increase of *Fagus*.	Gro-480	2870 ± 140
Emmen I (−42 cm): last *Corylus* maximum (C4 of Overbeck and Schneider).	Gro-426	3095 ± 150
Emmen II (−62 cm): the point where *Fagus* reaches a value of about 1 percent.	Gro-424	3350 ± 140
Emmen III (−119 cm): increase of *Plantago lanceolata*.	Gro-428	4185 ± 140
Emmen IV (−171 cm): last high *Ulmus* value.	Gro-431	4965 ± 135
Emmen IV (−171 cm): humic acid.	Gro-432	5120 ± 190
Emmen IV (−171 cm): material extracted by HCl. Obviously there is no significant difference between these fractions.	Gro-487	4830 ± 400
Emmen V (−250 cm): intersection of the lines for *Pinus* and *Alnus*.	Gro-429	7085 ± 210
Emmen IX (−260 cm): considerable increase of *Alnus*.	Gro-667 Gro-676	7745 ± 135 7880 ± 110
Emmen VIII (−280 cm): increase of *Corylus*. The pollen diagram, sample selection, and dates are dealt with by Van Zeist in a separate paper (*21*). Some important points are the following: the *Ulmus* fall at about 3000 B.C. (the same as in the profiles Vriezenveen and Tannenhausen; see below); the increase of plantain at about 2200 B.C.; the increase of *Fagus* to about 1 percent, corresponding to the transition from Neolithic to Bronze Age, at about 1400 B.C.	Gro-481	8630 ± 180
Vriezenveen (province of Overijsel). Seven samples from two partly overlapping sections in the large raised bog of Vriezenveen (*22*). Collected and submitted by F. Florschütz, Velp.		
Section I: Vriezenveen VI (28 to 30 cm); increase of *Carpinus*.	Gro-495	1260 ± 120
Section I: Vriezenveen VII (96 to 98 cm); increase of *Fagus*.	Gro-496	2370 ± 110
Section II: Vriezenveen V (20 to 25 cm); increase of *Fagus*.	Gro-491	2520 ± 100
Section II: Vriezenveen III (46 to 48 cm); immediately above the *Grenzhorizont*.	Gro-489	3540 ± 140
Section II: Vriezenveen IV (48 to 50 cm); immediately above the *Grenzhorizont*.	Gro-490	3425 ± 140
Section II: Vriezenveen II (53 to 55 cm); beginning of the continuous *Fagus* curve.	Gro-485	3365 ± 140
Section II: Vriezenveen I (90 to 92 cm); *Ulmus* fall.	Gro-484	4985 ± 140
The dates are in agreement with those from the other standard sections. The *Grenzhorizont* in this section appears to be very early; there is no significant difference between the dates on samples obtained below and above the *Grenzhorizont*.		
Tannenhausen (near Aurich, Ost Friesland, Germany). Five samples from a profile in a drained, raised bog about 5 km north of Aurich. The profile is considered as a standard profile to be used for the dating of submerged peat layers in the East Frisian coastal region (*23*). Collected and submitted by U. Grohne, Institut für Marschenforschung, Wilhelmshaven.		
Sample 5 (25 to 30 cm): fresh *Sphagnum imbricatum* peat; relatively high values for *Fagus* (± 10 percent) and *Carpinus* (5 to 6 percent); *Tilia* is absent.	Gro-321	1295 ± 130
Sample 4 (55 to 60 cm): fresh *Sphagnum imbricatum* peat; *Fagus* for the first time surpasses 4 to 6 percent; *Carpinus* remains below 1 percent; the *Tilia* curve is no longer continuous.	Gro-258	2395 ± 170

Description	Sample No.	Age
Sample 3 (81 to 87 cm): fresh *Sphagnum imbricatum* peat; *Fagus* exceeds 1.5 percent in this sample, and gradually increases toward the top.	Gro-259	2705 ± 120
Sample 2 (91 to 95 cm): humified *Sphagnum cuspidatum* peat; beginning of the continuous *Carpinus* curve, immediately above the last *Corylus* maximum (C4 of Overbeck and Schneider).	Gro-232	3075 ± 100
Sample 1 (155 to 160 cm): humified, *Calluna*-containing *Sphagnum* peat; last high *Ulmus* value at the transition from Atlantic to Subboreal.	Gro-231	4985 ± 120
From these dates one may conclude that the Atlantic-Subboreal boundary and the beginning of Neolithic agriculture, as shown by the presence of a few grains of *Plantago* and *Cerealia*, must be placed at about 3000 B.C. The transition from humified *Sphagnum cuspidatum* peat to fresh *S. imbricatum* peat took place shortly before 750 B.C. The dates closely correspond to those obtained in the Emmen standard section.		
Hilgenrieder Bucht (Ost Friesland, Germany). Two samples from a clay-covered, raised bog, about 10 km northeast of Norden. Distance to present coast marsh, about 1 km. Collected and submitted by U. Grohne.		
Sample 7 (section B3, 1.95 to 2.04 m): transition of humified *Sphagnum* peat to clay-containing *Sphagnum* peat. Beginning of continuous *Carpinus* curve, immediately above the fourth *Corylus* maximum.	Gro-324	3480 ± 120
Sample 6 (section B3, 2.43 to 2.48 m): Ubergangsmoor with monocotyledons, *Eriophorum*, Ericaceae, and *Sphagnum*; last high *Ulmus* value.	Gro-342	5360 ± 100
Sample Gro-342 is somewhat older than might be expected on the basis of the Tannenhausen results. Sample Gro-324 is about 500 years older than the corresponding sample from Tannenhausen. In this case, however, the deviation may have been caused by the redeposition of older peat material.		
Northeastern Polder (former Zuiderzee). Two samples from peat layers which have been correlated with a marine clay sediment (*Cardium* clay). This clay used to be considered as Atlantic, but nowadays a date of about 1800 B.C. is accepted.		
One sample is from Schokland (P.6); it consists of a clayey peat.	Gro-377	3315 ± 90
The other sample is from Urk (D 135); it is from the peat layer immediately below the clay and indicates the beginning of the transgression.	Gro-378	3505 ± 120
These dates prove the supposed subboreal age of the *Cardium* clay. For a detailed discussion, reference may be made to Wiggers (*11*, pp. 63–65, Fig. 24), who collected and submitted these samples.		
Hauwert (West Friesland, province of Noord Holland). Four samples from a profile at Hauwert; the profile is of importance for the study of marine transgressions in the area. The pollen analysis of the section has been made by Florschütz. The samples were collected and submitted by P. Ente and L. J. Pons, Stichting Bodemkartering, Bennekom.		
Sample HZS-a: depth, 1.10 to 1.35 m; shells.	Gro-617	3240 ± 140
Sample HZS-b: depth, 1.45 to 1.55 m; reed peat.	Gro-609	3750 ± 120
Sample HZS-c: depth, 3.35 to 3.45 m; sedge-reed peat.	Gro-610	4090 ± 120
Sample HZS-e: depth, 3.85 to 3.95 m; reed-containing sedge peat.	Gro-605	4690 ± 140
The results agree well with what was anticipated on the basis of palynological and geological considerations.		
Giersbacher Moor (Schwarzwald, Germany). Two samples from a peat profile in the southern part of the Black Forest (*24*). Collected and submitted by G. Lang, Karlsruhe.		
Sample 1 (68 to 75 cm): end of *Abies* period.	Gro-319	3015 ± 120
Sample 3 (155 to 163 cm): beginning of *Abies* period.	Gro-273	4465 ± 140
The dates confirm the view that the *Abies* period in the Black Forest should fall within the Subboreal. Formerly it was thought to belong to the Atlantic.		
Derrybrien North (county Galway, Eire). Peat containing amber bead. A group of several hundred amber beads of Late Bronze Age type were found at the base of a shallow blanket bog at Derrybrien North. Above the level of the beads the pollen sequence was marked by a fall in *Ulmus* to low values. The expected age was in the last centuries of the Pre-Christian Era. Collected and submitted by G. F. Mitchell, Trinity College, Dublin. The date is a little younger than was anticipated, but there is no reason why such necklaces should not still have been in use at the beginning of the Christian Era.	Gro-650	1870 ± 90
Corlona (county Leitrim, Eire). Wood (oak) from a trackway in Corlona Bog (*25*). Depth about 0.95 m. Collected by P. Tohall and submitted by W. van Zeist. According to the pollen diagram by Van Zeist as interpreted by G. F. Mitchell (*26*), the level of the trackway would fall in the beginning of Mitchell's revised zone VIII^b.	Gro-272	3395 ± 170
Clonsast (county Offaly, Eire). Wood from *Pinus* stump at a depth of about 75 cm in the raised bog at Clonsast (*26*, pp. 202–206, Fig. 6). The stump was immediately below a recurrence surface. At a slightly higher level the pollen sequence was marked by an abrupt fall in *Ulmus* to low values. The expected age was in the first centuries of the Christian Era. A piece of wood from the same stump was also submitted to the Yale Geochronometric Laboratory. The Yale determination was (Y-94) 1610 ± 80 yr. The results, which overlap very satisfactorily, suggest that the recurrence surface may perhaps be equated with RY-II of Granlund, which was dated at Yale to A.D. 400.	Gro-271	1485 ± 150
Wood from trackway embedded in upper fresh peat in the same raised bog at Clonsast (*26*, pp. 202–206, Fig. 7). Values for *Ulmus* pollen at the level of the trackway were low. The expected age was about A.D. 900. The date of the track is a little younger than was anticipated, but the age is a very reasonable one. These two samples were collected and submitted by G. F. Mitchell.	Gro-651	975 ± 80

Table 3. Archeological samples. All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
I. *Europe.*		
Waskemeer (province of Friesland). Charcoal from culture layer with flint artifacts of the Tjonger culture ("Federmesser Gruppe") at Waskemeer. The layer was situated in coversand at a depth of 120 cm, about 30 cm below the Usselo horizon. Collected and submitted by A. Bohmers.	Gro-607	10,800 ± 230
Horn-Haelen (province of Limburg). Charcoal from Usselo horizon with artifacts from the Tjonger culture at Horn-Haelen. Collected by Brother A. Wouters, submitted by A. Bohmers.	Gro-497 Gro-498	11,000 ± 320 10,950 ± 300
Leende (province of Noord Brabant). Collected in the Usselo horizon, which locally was very rich in charcoal. In the coversand, immediately above this layer, artifacts of the Ahrensburg culture were found.	Gro-603	11,020 ± 230
Charcoal from the culture layer has recently been dated. Both samples collected and submitted by Brother A. Wouters and A. Bohmers.	Gro-1059	10,720 ± 85
Nederweert (province of Limburg). Charcoal from culture layer with artifacts from the Tjonger culture at Nederweert. This layer was situated at a depth of about 40 cm in a coversand deposit. Collected and submitted by A. Bohmers.	Gro-908	9315 ± 110
Lommel (Belgium). Charcoal found in coversand with artifacts from the Tjonger culture. Depth about 40 cm. Collected and submitted by H. T. Waterbolk and A. Bohmers.	Gro-911	7550 ± 90
This is a series of charcoal samples found in connection with Paleolithic cultures. A preliminary survey of the Dutch Paleolithic has been published by Bohmers (*27*), who is now preparing a survey of all Paleolithic finds in the Netherlands. The charcoal samples from Donderen and Een, the dates of which have previously been published, may be commented upon in this connection as well.		
Hamburgian of Donderen. Tjongerian of Een.	Gro-216 Gro-236	7365 ± 400 7030 ± 140
At Horn-Haelen and Leende (sample Gro-603) the charcoal has no relation to the human occupation of the sites; the dates refer primarily to the Usselo layer which, on the basis of stratigraphic evidence, was expected to be of Alleröd age. Other dates of the Usselo layer are given in Table 2. They all appear to lie at the transition between the Alleröd and the Younger Dryas period. The ages of the other samples (Waskemeer, Nederweert, Lommel, Donderen, Een) are not in accord with expectation. At Waskemeer, the charcoal, although clearly below the Usselo layer, still has the same age. In the other cases the difference is even greater and in contradiction to other radiocarbon dates, if we accept well-founded geological and archeological synchronizations. At Donderen, Lommel, and Nederweert the charcoal was present in the form of diffusely spread small particles at a relatively small depth (less than 50 cm). The possibility may perhaps be considered that the presence of charcoal in these cases is due to the action of the soil fauna and plant roots. This matter needs further investigation. The date of Een cannot, however, be explained in this way.		
Schussenquelle (Bavaria-Württemberg, Germany). Marly moss peat and reindeer antler from the well known Magdalenian site at the Schussenquelle. The peat sample (layer D, No. 27) was collected by G. Lang, who made a new pollen profile. The thickness of the moss peat is 77 cm; the sample came from the lower part (10 to 20 cm above the base) and belongs to pollen zone Ia. The antler is from the 1867 excavation. At that time the objects from the find horizons were not separated; the antler might therefore also come from the upper layer of moss peat, which probably belongs to pollen zone Ib. The antler might have been sized. Submitted by H. Gross, Bamberg.		
Moss peat. Antler.	Gro-468 Gro-469	14,470 ± 385 11,580 ± 290
After our pretreatment it is unlikely that the antler should have been rejuvenated by the sizing. Even if it should have come from the upper layer (zone Ib, that is, Bölling) the date obtained could hardly be correct. Washington dates from Meiendorf and Stellmoor would point to a consistent error inherent in antler. This matter is under further investigation. The peat date is a very reasonable one, though the high carbonate content might suggest a possible uptake of older carbonate by the mosses and the other constituents of the peat. Gross does not believe this to be a serious error, for the mosses would have taken up CO_2 from the air.		
Pesse (municipality of Ruinen, province of Drente). Wood (*Pinus*) from a dugout canoe found at a depth of 2 to 2.50 m in a small bog near Pesse. According to pollen analysis, the canoe would be of middle Boreal age (alder only 0.1 percent). Collected and submitted by W. van Zeist. The sample was submitted because the possibility could not entirely be excluded that the dugout had sunk into the peat at a later date. The radiocarbon date, however, agrees well with the pollen determination. This is the oldest dugout canoe now known.	Gro-486	8270 ± 275
Waskemeer (municipality of Ooststellingwerf, province of Friesland). Charcoal from a fireplace belonging to a Mesolithic settlement at the surface of the Younger coversand at Waskemeer. In the same section Paleolithic finds (see Gro-607) occurred. Collected and submitted by A. Bohmers. The artifacts belong to the same Mesolithic stage (Halterner Stufe, according to Schwabedissen) as those from the nearby settlement of Haule. From the latter place charcoal has been dated (*1*) at 7525 ± 200 yr (Gro-128). A Chicago measurement yielded 7900 ± 300 yr. According to pollen analysis, Haule would be of late Boreal age. The radiocarbon dates agree well with this determination.	Gro-615	7455 ± 120
Sittard (province of Limburg). Charcoal from a pit ("Wohngrube") at Sit-	Gro-320	6100 ± 140

Description	Sample No.	Age
tard, which was investigated in 1949 (*28*). It yielded, among other shards, a fragment of a beaker-with-a-protruding-foot, which, according to Sangmeister, would indicate a late stage of the *Bandkeramik*. Collected and submitted by W. Glasbergen.		
Sittard (province of Limburg). Two charcoal samples from the 1953 excavation (*29*) of a large Danubian settlement on the Stadswegske, Sittard. On the basis of archeological evidence, sample Gro-423 was expected to be the younger one. Glasbergen's pit is situated in the younger part of the settlement as well. Collected and submitted by P. J. R. Modderman, Rijksdienst voor Oudheidkundig Bodemonderzoek, Amersfoort. Samples Gro-320 and 423 agree with each other; against expectation, Gro-422 is somewhat younger. However, the difference is small. The present results confirm the unexpectedly great age of the *Bandkeramik*, which had appeared in the dates (*1*) of Westeregeln (Gro-147, charred wheat, 6200 ± 200 yr) and Wittislingen (Gro-265, charred wood, 6030 ± 110 yr). This differs from current views by about 1500 years!	Gro-422 Gro-423	5790 ± 190 6200 ± 150
Wahlitz (Kreis Burg, East Germany). Charred grain from culture layer belonging to the Rössen culture at Wahlitz (*30*). The sample number is 181/8 (find complex 37). Submitted by W. Rothmahler, Institut für Agrobiologie, Greifswald. In the light of the *Bandkeramik* dates, the age is very reasonable: the Rössen culture is commonly considered as early Neolithic, though younger than *Bandkeramik*.	Gro-433	5300 ± 200
Burgliebenau (near Merseburg, East Germany). Charred grain from a storage pit 1.75 m deep, excavated in 1916 (*31*). The sample is pure and reliable. Expected age, late Neolithic. Submitted by W. Rothmaler. This date agrees well with the current conception of the beginning of the Bronze Age in Middle Germany (about 1800 B.C.).	Gro-434	3900 ± 150
Durrington Walls (Wiltshire, England). Charcoal from the excavation of Durrington Walls. Collected and submitted by Stuart Piggot, Edinburgh, Scotland. Sample Gro-901a was an earlier measurement. According to Piggott, the date is much older than was expected and contrary to archeological evidence. The site must be approximately contemporary with the first stage of Stonehenge, for which a Chicago date of 3800 ± 275 yr is available. More determinations are needed.	Gro-901 Gro-901a	4584 ± 80 4575 ± 50
Hekelingen (Isle of Putten, province of Zuid-Holland). Charcoal from a Neolithic settlement in the alluvial coastal region at Hekelingen. The settlement was situated on a creek bank (*32*). According to Glasbergen, the pottery is identical with that found at Zandwerven, below a layer containing beakers-with-a-protruding-foot. It would correspond to that of the Seine-Oise-Marne culture of France and Neolithic coastal cultures in Belgium. Collected and submitted by P. J. R. Modderman.	Gro-254	4200 ± 120
Schaarsbergen (municipality of Arnhem, province of Gelderland). Charcoal from central grave of tumulus I at Schaarsbergen. In the grave, an early beaker-with-a-protruding-foot, a flint axe, and a flint blade were found. The quantity of charcoal was small.	Gro-318	4435 ± 320
Ede (province of Gelderland). Charcoal from central grave of tumulus I at Hotel Bosbeek (*33*). The grave contained an early beaker-with-a-protruding-foot, a faceted battle-axe, and a flint blade. Collected by P. J. R. Modderman and submitted by W. Glasbergen.	Gro-330	4195 ± 120
Bennekom (province of Gelderland). Charcoal from central grave and corresponding post circle in Oostereng (*34*). The grave contained two bell beakers of the Veluwe type. Collected and submitted by A. E. van Giffen, Biological Archeological Institute, Groningen.		
Charcoal from grave.	Gro-374	3560 ± 130
Charred post.	Gro-326	3865 ± 180
Witrijt (municipality of Bergeijk, province of Noord Brabant). Charcoal from foundation trench around the central grave of a tumulus at Witrijt. In the grave a beaker with herringbone ornamentation and a knife of Grand Pressigny flint. Collected and submitted by G. Beex and P. J. R. Modderman.	Gro-381	3965 ± 150
Eext (municipality of Anlo, province of Drente). Charcoal covering central grave of Neolithic barrow. During the 1956 excavation only part of the grave was found intact; it contained a battle axe. However, amateurs had collected from this barrow, most probably from the same grave, a beaker and a dagger of Grand Pressigny flint. Sample collected and submitted by one of us (H. W.) A more detailed discussion of the Dutch radiocarbon dates from the Neolithic and Bronze Age has been prepared by Glasbergen (*35*). The following comment is mainly based on the manuscript Dr. Glasbergen kindly put at our disposal. The dates of Schaarsbergen and Ede are of great importance. They refer to typical beakers-with-a-protruding-foot, a type which appears to start at an earlier date than hitherto accepted. The new dates, however, are in agreement with the views expressed by Van der Waals and Glasbergen in their recent study of Dutch beakers (*36*). According to expectation, the Hekelingen date is somewhat earlier. Finally, we may point to the date of the increase of plantain in the standard profile of Emmen (4185 ± 140 yr). This increase seems to be effected by the "protruding-foot-beaker" culture. Whenever such beakers and bell beakers in the Netherlands occur in a stratigraphical context, the latter appear to be the younger. The Bennekom dates are in agreement with this. The beaker of Witrijt, a bell beaker influenced by the "protruding-foot-beaker" culture, appears to be somewhat older than was expected.	Gro-939 Gro-946	3645 ± 65 3640 ± 50
Ermelo (province of Gelderland). Charcoal from a burnt beam, found at the foot of tumulus VII (Elspeetse Heide) (*33*, pp. 21–33). Such charred		

Description	Sample No.	Age
beams were found encircling two other barrows in the same area. Although no datable objects were found, these barrows were expected to date from the Early or Middle Bronze Age.		
Sample No. 38.	Gro-447	3375 ± 150
Charcoal samples from cremations, which, on the basis of archeological and pedological considerations, were expected to belong to the earliest part of the Bronze Age.		
Tumulus IV.	Gro-445	2840 ± 140
Sample No. 30, tumulus XIVa.	Gro-446	2995 ± 120
Sample No. 47, tumulus VII.	Gro-448	2820 ± 140
Charcoal from a burnt palisade around tumulus V in the Speuldersveld (Sample No. 84).	Gro-451	2935 ± 140
The Ermelo samples were collected and submitted by P. J. R. Modderman. The age of Gro-447 and 451 is according to expectation. Samples Gro-445, 446, 448 are much younger than was anticipated. Apparently the previous view, mainly based on pedological grounds, is wrong; the cremations date rather from the Middle Bronze Age.		
Myon (municipality of Myon, Doubs, France). Charcoal from a ditch at Bra, near the plateaux of Alaise. This ditch was found in 1861 by A. Castan and identified with the oppidum of Alesia, mentioned by Caesar. In 1954 the ditch was found again. The sample was collected at a depth of 2 to 2.20 m; no datable objects were found. If Castan's suppositions were correct, the date would fall between 50 B.C. and A.D. 50. Submitted by Professor J. Berard and collected by L. Déroche, University of Nancy, France. Apparently the charcoal layers originated long before the Roman occupation; the sample cannot be identified with Alesia.	Gro-369	2605 ± 130
Ermelo (province of Gelderland). Charred wheat and barley, found in a pit together with some Iron Age shards, in the vicinity of Ermelo. So far the largest find of prehistoric grain in the Netherlands. Owing to earlier diggings at the site, the contemporaneity of shards and grains was not certain. Collected and submitted by H. T. Waterbolk and W. van Zeist. The date confirms the supposed age.	Gro-652	2295 ± 100
Nijmegen (province of Gelderland). Charcoal found at a depth of about 2 m in a layer containing traces of a destruction (NS 54). It is thought that this devastation was due to the Norse raid in 880. In the same layer, pottery from the 9th to the 12 century was found, including Pingsdorf ware and ware with early glaze. Collected and submitted by H. Brunsting, Rijksmuseum, Leiden. The date agrees well with the assumption.	Gro-649	1050 ± 80
II *America, Africa.*		
Mayapan (Yucatan, Mexico). Charcoal, apparently from burned roof beams, on the floor of structure Q-142 in the main ceremonial group at Mayapan. The sample is from a building that seems to have been erected late in the life of the city. Expected age, approximately 500 yr.	Gro-450	355 ± 90
Charcoal from lower levels of a trench at the foot of the north stairway of the principal temple, the Castillo (structure Q-162) at Mayapan. Sample is associated with pottery and construction apparently marking the earliest phase of the principal period of occupation of the city. Expected age, approximately 700 yr. Submitted and commented on by H. E. D. Pollock, Carnegie Institution of Washington.	Gro-452	700 ± 95
Historical and archeological evidence indicates that the principal period of occupation of the city of Mayapan must have occurred between approximately A.D. 1200 and 1460. The two samples were selected with the idea of dating as nearly as possible the beginning and end of the period. The date of Gro-452 (sample B) bears out the archeological and historical evidence. The date of Gro-450 (sample A) is 160 years later than the date of the traditional destruction of the city and falls in post-Columbian times. The discrepancy may partly be due to "Suess effect" (see introduction).		
Uxmal (Yucatan, Mexico). A piece of sapote heartwood from the lintel of a door in the ape house at Uxmal. Sample collected by Buz l'Huiller, submitted and commented on by R. A. M. Bergman, Koninklijk Instituut voor de Tropen, Amsterdam. Uxmal is considered the oldest settlement of the Mayas in Yucatan after the end of the "old empire" in Honduras and Guatemala, which was left between A.D. 750 and 950. Then the "New Empire" was founded in Yucatan; this was taken by the Toltec between the years A.D. 1000 and 1100. The style of Uxmal is older than the one in Chichenitza and Mayapan, where Toltec influences are discernible. The dating found by the C^{14} method is in excellent agreement with these observations.	Gro-613	1065 ± 100
Irazu (Costa Rica). Sample of charcoal found under a lava stream during the construction of a road. Collected by Mrs. Doris Stone, submitted and commented on by R. A. M. Bergman. This charcoal belongs to a layer showing pottery of the Guetar culture, an Indian people of which no dating is known. Neither is the date known of the volcano eruption which covered the site. For both reasons the dating with C^{14} is very welcome, first because the Guetar culture can now be dated, second because it brings to our knowledge the date of this eruption of the Irazu.	Gro-614	960 ± 100
Paracas. A piece of wood found about 1 m under sand together with shards of pottery, fragments of tissue of the kind used for wrapping mummies, and a skull presenting a markedly elongated deformation. The site is a grave, probably opened previously. Collected and submitted by H. Feriz, commented on by R. A. M. Bergman. The oldest layer of this necropolis has been dated at 600 ± 180 B.C. According to Bird, the elongated deformation appeared at about 400 B.C. The Nasca culture, which is considered to follow the Pa-	Gro-618	1765 ± 155

Description	Sample No.	Age
racas culture, is thought to start at A.D. 100. The present find, which pertains to the younger layers of the Paracas culture, is very interesting, for it suggests that the elongated cranial deformation was practised until the end of the Paracas culture, and that the change from Paracas to Nasca culture was indeed rather an abrupt one.		
Saqqara (Egypt). Piece of wood from a mastaba (Saqqara 3505). End of the First Dynasty (reign of Ka). Accepted age about 4800 yr before the present).	Gro-902	4145 ± 70
A second sample from the same locality, tomb 3507 (Saqqara 1955–56). Post of wooden roller across a big niche, embedded in the brickwork. Middle of the First Dynastry (reign of Den). Accepted age about 4900. Unfortunately the sample did not contain enough material for measurement in the medium-sized counter. These samples were collected and submitted by A. H. Klasens, Rijksmuseum, Leiden. In our first report (*1*) a dating of a Badari sample was given (Gro-223, age 5110 ± 160 yr). Both the samples from the First Dynasty and this Badarian sample come out "too young." The interval between the two periods is not unreasonable. Further measurements are planned.	Gro-689	4450 ± 100

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News of Science

AIBS Protests Civil Service Action on Pay for Scientists

Approximately 28,000 biologists on the Federal payroll did not benefit from recent pay increases granted by the Civil Service Commission [*Science* **127**, 21 (3 Jan. 1957)]. On 10 December the Civil Service Commission announced pay increases for "scientists" employed by the Federal Government, but biologists, agriculturists, and bacteriologists were not included. The raises were granted to physicists, mathematicians, engineers, some chemists, and a number of technologists.

Hiden T. Cox, executive director of the American Institute of Biological Sciences has protested the action in a letter that was sent to President Eisenhower; his scientific adviser, James R. Killian; the Secretaries of Defense, Agriculture, Commerce, Health, Education and Welfare, and Interior; the chairman of the Civil Service Commission; and the chairman of the House and Senate Committees on Civil Service, Government Operations, and Agriculture.

The presidents and secretaries of all societies affiliated with the AIBS also received letters from Cox explaining the situation and pointing out the serious consequences, present and future, to biology. Many of the society officers have, in turn, written to the above officials, as well as to their individual state senators and congressmen. It is understood that the Civil Service Commission has begun a study of the availability of biologists and the salary scales paid by industry and academic institutions. Opposition to the Civil Service Commission action was taken on the grounds that:

1) While there may be no serious quantitative shortage of biologists at the present time, there are growing shortages in certain areas. Moreover, there are qualitative shortages in almost all fields of biology, and many are in areas critical to the national defense effort.

2) The Civil Service action is discriminatory and makes second-class scientists out of biologists. The financial discrimination is real enough but the discrimination against the prestige and importance of biological scientists is much more significant.

3) The lowering of morale among Federally employed biologists can already be seen.

4) The effect of this action upon future recruitment of superior students into the biological and agricultural sciences is serious. The fact that biologists appear to be considered second-rate by the Federal Government cannot fail to reflect itself in a reduction in the numbers of students attracted to biology.

5) Science must advance in all fields, not in just a few. Artificially stimulating certain areas, even for political expediency, is extremely shortsighted.

In a statement to the press, the American Institute of Biological Sciences emphasized that it does not intend simply to register protests. The statement said:

"The Institute was established in 1948 as the national organization for professional biological societies to speak for the science and to plan effective cooperative action that will advance the research and teaching efforts of all participating biologists.

"The Institute has, in recent weeks, been instrumental in having the first biological representative named to the IGY Space Satellite Panel. The United States alone among cooperating nations has no organized biological program in the International Geophysical Year. Since the ultimate purpose of a space satellite program is to put life—man—on a space platform, the role of biology seems obvious. An *ad hoc* AIBS Committee has been advising the Office of Naval Research on the design and development of a biological experiment to be included in an early U.S. satellite. A member of this Committee, Dr. Otto Schmitt (University of Minnesota) is the newly appointed member to the U.S. Space Satellite Panel. The AIBS, through this Committee is now planning a Symposium on 'Biology in the Space Age.' Tentatively the Symposium is planned for the 1958 annual AIBS meeting for biologists, to be held at Indiana University, Bloomington, August 24–28.

"Biological research results of the last fifty years are impressive. Improved world food production has virtually eradicated famine. This has been accomplished by the development of new hybrid crops, disease resistant grains, improved animal stocks, increased harvests from the sea, and the recent development of insecticides, fungicides and growth substances. The discovery and production of a spectrum of antibiotics, the almost complete conquest of communicable diseases, the application of plant taxonomy to jungle survival techniques are other notable advances.

"Many of the most important scientific problems that remain to be solved are biological—methods for protection against atomic radiation and fallout; solution to the mystery of how green plants provide man with the air he breathes and the food he eats, without which he could not survive; and the problem of the future—how to maintain human life for indefinite periods in submarines and manned space vehicles.

"The Institute represents nationally the men and women who will solve these problems in the next few years. It is for these reasons that the AIBS is concerned, at the moment, with the action of the Civil Service Commission, and continually with the need to develop and encourage a well-qualified corps of biological scientists in the United States."

Conquest

CBS Television's *Conquest* will present its second program at 5 P.M. on 19 January. The telecast will deal with the following subjects: the life and accomplishments of Gerard Kuiper, director of the University of Chicago's two observatories, the Yerkes Observatory in Wisconsin and the McDonald Observatory at Fort Davis, Tex.; the story of H. Julian Allen, an aerodynamicist who, by redesigning the shape of rockets and missiles, has solved the crucial "re-entry problem," enabling objects to return to earth from space without burning up through friction with the atmosphere; and a special round-up of the scientific work being done around the world in connection with the International Geophysical Year, including interviews with leading American scientists cooperating in the international scientific effort. *Conquest* is being presented in cooperation with the AAAS and the National Academy of Sciences and under the sponsorship of the Monsanto Chemical Company.

Soviet Science Overestimated

Amid a growing number of claims that science in the U.S.S.R. may more than match that in the United States, Donald J. Hughes, a physicist with the Brookhaven National Laboratory, reports that the Soviet achievement in basic research is being overestimated in this country. Writing in the December issue of *Physics Today,* Hughes bases

his opinion on a two-week visit last summer to the Soviet Union as a guest of the Soviet government. Accompanied by his wife, Hughes also spent two weeks in Poland as a guest of the Polish Government.

The purpose of the visits was to lecture and consult on individual matters, not to attend a particular conference. This circumstance, Hughes says, produced an informal atmosphere favorable to learning about a wide variety of physics research as well as an opportunity to talk at length to many individuals. Among his specific comments on the state of science and on science as a way of life in the Soviet Union are the following:

Basic research. ". . . the Soviets certainly do not lead in basic research and in fact in most of its branches lag behind us. They do excel in certain fields, largely development of large equipment, where they have decided to devote intense effort. . . . Such things as the Soviet atomic power plant, the 10-Bev accelerator, and the earth satellite are very good examples of this type of evidence. . . . These developments, however, are not basic science and are the type of things that can be pushed to rapid success if funds are not limited."

Standard of living. "At levels above beginning PhD's the salaries seem to remain at about half those in the U.S. in terms of real purchasing power. This information may come as a surprise when compared with the stories that have been current about Soviet scientists having cars, chauffeurs, and homes in the country. These stories certainly do not apply to the scientists with whom I talked, men usually at the level of PhD's plus 5 to 20 years of experience. The only way in which these stories do apply is to the very few men who are members of the Academy . . . very few of the men we met owned cars of their own, and they all lived in rather small flats."

Effects of government control. "With the dictatorial control that is expressed by the Academy it is obviously true that certain fields can be picked to be pushed with all effort. It is difficult to say just why certain things are selected for the push, but it seems that spectacular items often are, and when success is achieved, as with the recent satellites, the propaganda value is utilized to the utmost. This kind of pressure on selected topics does not work well at all, on the other hand, in basic research and it is here that the Soviets lag behind us. . . . It is hard to see how basic science can advance in a situation in which a few fields, usually those that will produce results of propaganda value, are the only ones that are pushed."

Separation of scientific work from political opinion. ". . . the day we arrived in Russia . . . there were two letters to the editor in an English-language Soviet newspaper. These letters, supposedly voluntarily submitted, were by Skobeltzyn, Director of the Nuclear Institute, and Mescheryakov, head of one large phase of research at the Dubno laboratory [Joint Institute of Nuclear Research at Dubno, about 60 miles north of Moscow]. . . . The letters expressed extreme hate for the West yet the day after reading these letters in the paper we were talking to Mescheryakov, who explained his experiments as a typical scientist, extremely friendly and vitally interested in our experiments as well as his own. The impression we gained from this and other experiences was that the scientists learned to separate their scientific work, which may be of high caliber, from propagandist political activities sponsored by the government."

Sardis Expedition

An archeological expedition to ancient Sardis in Turkey is planned next summer by Cornell University, the American Schools of Oriental Research, and the Fogg Museum of Art of Harvard University. Sardis was the city of King Croesus, who was renowned as the richest man in the world and was credited with having introduced coinage. The expedition plans were announced recently by A. Henry Detweiler, Cornell professor and president of the American Schools of Oriental Research, an organization that has research and archeological centers at Jerusalem and Baghdad that are supported by more than 100 American universities and seminaries.

AAAS Newcomb Cleveland Prize

M. Schwarzchild and J. B. Rogerson, Jr., both of Princeton University Observatory, and J. W. Evans, executive director of the Sacramento Peak Observatory, received the thirtieth AAAS Newcomb Cleveland Prize of $1000 during the Association's recent meeting in Indianapolis. The men were honored for having developed techniques for obtaining direct solar photographs with high definition undisturbed by the blurring effects of the earth's atmosphere. In a paper entitled "Solar Photographs from 80,000 feet," Rogerson presented the results of the prize-winning project.

Three unmanned balloon flights were carried out to secure the high-quality photographs of the sun. These photographs should enable scientists to gain a better understanding of the turbulence in the solar atmosphere. Several exposures of very high definition were obtained, both of the center of the solar disk and of the limb, or edge, of the solar disk. These exposures show that the solar granulation (boiling in the solar atmosphere) has a cellular, though highly irregular, structure. The bright cells appear separated from each other by dark, and often very sharp, lines. There seems to be a continuum of granule diameters from the smallest observable with the balloon telescope (250 km) up to the sizes previously observed (700 to 1400 km).

The techniques of photographing solar granulations from a balloon-supported platform will be applicable to many other astronomical problems which are at the present time limited by the blurring of the earth's atmosphere. The solar surfaces can be seen in much more detail; turbulence around sun spots and other magnetic areas can be studied. The techniques may be applicable to the study of turbulent motion on other stars; this motion appears to have significant effects on the evolution of many stars.

The project has been sponsored by the Office of Naval Research and by the geophysics Research Directorate of the Air Force. Lyman Spitzer, head of Princeton Observatory, has been closely connected with the project in an administrative capacity.

Laurence H. Snyder, president of the AAAS, presents the Newcomb Cleveland Prize to J. B. Rogerson, Jr., one of the three winners of the association's $1000 award.

Mental Health and Atomic Energy

A study group of the World Health Organization, at a meeting held in Geneva, announced late in November that it has examined reports from many countries concerning the emotional impact of developments in atomic energy as reflected in everyday life, in public statements, in the press, and in letters to leaders in the atomic, health, and political fields. Members of the group found that, in general, irrational fears were expressed far more often than irrational hopes and suggested that this might be owing to the fact that people were first made aware of radiation as a means of diagnosing or treating two dreaded diseases, tuberculosis and cancer. It was found, further, that the use of atomic energy as a weapon has aroused a deep sense of fear and, in some people, also of moral involvement and guilt.

The group considered that there are also other factors that have influenced public attitudes toward atomic energy. One is the aura of mystery that surrounds the subject of atomic power. Atomic radiation is invisible, unheard, unfelt, apparently infinitely powerful, and yet it springs from a very small source and, as far as ordinary people are concerned, is uncontrollable. It is credited with almost countless potentialities for both good and evil and represents man's most amazing success in his search for power. Ancient myths and legends common to many races show that man's quest for power often results in terrible divine punishment: Prometheus stealing fire from the gods, Pandora unleashing forces she could not control, Faust evoking the Devil, the alchemists of the Middle Ages—all paid a heavy penalty for their daring. These tales were found in one form or another in nearly all cultures, as witness an ancient Egyptian saying: "When man learns what moves the stars, the Sphinx will laugh and life will be destroyed."

Perhaps the most terrifying aspect of atomic energy, in the popular imagination, is the possibility that its tremendous power may get out of control. People are also beginning to fear a biological chain reaction: fall-out and atomic wastes would poison air, water, and soil, then plants and cattle, then the men who eat them, and, above all, their children and their descendants. This, the study group found, is a deeper and more subtle fear than that of the unleashing of energy that might destroy the universe.

The WHO study group further found that there is a widespread sense of disorientation in regard to atomic energy matters and a mistrust of most sources of information. For this state of affairs, they said, there are many past and present causes: wars, psychological warfare, political propaganda, and so on. Even competitive commercial advertising has contributed its share. Furthermore, science today has lost the reputation for infallibility which it possessed in the 19th century, and the publicizing of disagreements and contradictions among scientists—about polio vaccine or the cancer-producing effects of tobacco, for example—have contributed to this mistrust. Although a certain section of public opinion will always continue to place confidence in authoritative declarations, one can note in many countries a general mistrust of scientific pronouncements. This mistrust is often reflected in deliberately antiscientific attitudes.

Among other factors which have contributed a disturbing background in the emergence of atomic energy is science fiction, which has steadily stressed the horror of scientific power, the "death ray," and the "mad scientist."

These, according to the study group, are some of the more serious obstacles in the way of establishing public confidence in the peaceful uses of atomic energy and underlie the unreasonable fears aroused by this new source of power.

Unreasonable hopes also exist among people in both the developed and the underdeveloped countries, and these may lead not only to local dissatisfaction but also to a real danger for the whole world. Many people expected immediate returns from atomic energy in terms of prestige, conveniences, and a higher standard of living that would, for the first time, put poor countries on a par with the richest and most highly developed. They pressed urgently for these benefits and were bound to be disappointed, because new ways of life and many technical skills were needed before changes could be accomplished. The disparity between aspirations and results could well be catastrophic and lead to hostile attitudes. It is perhaps in this aspect of the problem of atomic energy that the greatest potential danger is to be found, according to the study group.

Members of the study group found that, in many countries and at many levels of society, and even among scientists, there is a feeling that there are no mental health, or even morale, aspects of the problem of atomic energy. This may be in part a sign of the general disinclination to face psychiatric problems—a disinclination against which the mental health movement has had to struggle for years. But the experts feel that avoidance and rejection of the subject is probably in itself a sign of anxiety, exemplifying the fact that rational thought is sometimes blocked for emotional reasons. The group expressed the fear that this denial of the problem could lead to over-confidence and to further difficulties and added that research into this matter is of urgent importance.

The group found that every type of psychological reaction to atomic energy is met with—acute and marked fear, belittling of the importance of the whole situation, or ridicule. But except for those who show apathy—and this in itself may be an unhealthy sign—atomic energy never fails to make people react.

The WHO authorities think that the complexity of underlying emotions in the changing environment of the second industrial revolution, brought about by the atomic age, needs to be recognized more widely by leaders of thought and action. The first task, they said, seems to be to establish what might be termed a culture of change, in which change and reorientation can take place without upheaval. The chief effort will have to be directed toward securing for adults a greater intellectual grasp, and thus a better understanding, of the new situation.

The group feels, however, that the main duty of the present generation is toward its children. Their upbringing must enable them to put up with insecurity and to face reality. This upbringing must be free from anxiety and hate and must produce self-reliance and a sense of responsibility toward others. And those who hold responsible positions in public life—doctors, teachers, the clergy, government authorities—must be educated in mental health requirements.

So far as local action is concerned, the group discussed a draft plan for the education of the community in matters pertaining to atomic energy. In essence, the idea is to form small teams consisting, for example, of a psychiatrist, a psychologist, and a sociologist, and a journalist. This team would study local conditions and contribute to the planning of new atomic enterprises and to their acceptance by the people.

With regard to the press, the group was impressed by the general standard of integrity with which journalists handle atomic energy news. Yet, regrettably, this news is often presented under scare headlines, which contribute to the anxiety of the reading public. They felt that journalists could be educated to understand more of the implications of the news they had to handle and suggested that authorities in the atomic energy field provide a really effective information service for the benefit of the press.

In conclusion, the group stated that its findings are in no way alarming. It is, however, convinced that they are concrete enough to warrant the attention of those in authority. The group hopes that persons in authority will be prepared to accept its conclusion that the behavioral sciences can make a valuable and concrete contribution to man's adaptation

to the advent of atomic power, making this adaptation as painless and harmless as possible and allowing man to reap a rich harvest from the seed his inventive genius has sown.

The WHO Study Group on the Mental Health Aspects of the Peaceful Uses of Atomic Energy included: Austen M. Brues, Argonne National Laboratory, Lemont, Ill.; Brock Chisholm, former director-general of WHO, Victoria, British Columbia, Canada; A. H. Leighton, Center for Advanced Study in the Behavioral Sciences, Stanford, California; J. S. Riach, Marie Curie Hospital, London; Kenneth Soddy, assistant director, World Federation for Mental Health, London; Ritchie Calder, science writer, London; Hans Hoff, University of Vienna, *chairman*; P. J. Reiter, Kommunehospitalet, Copenhagen; and A. M. Tubiana, Institut Gustave Roussy, Villejuif, France. The secretariat was composed of E. E. Krapf, chief, Mental Health Section of WHO, and Maria Pfister, medical officer, Mental Health Section of WHO.

News Briefs

P. R. Mallory & Co., Inc., Indianapolis, Ind., has received the 1957 AAAS Industrial Science Achievement Award for the development of the Steelmet process, which extends the use of powder metallurgy to entirely new fields. The Steelmet process eliminates the expensive multiple pressing and sintering required by other powder metallurgy processes and obtains dense structural parts from inexpensive raw materials. This annual award, which was established in 1956, is administered by the AAAS Industrial Science Section.

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During the past 6 months, the Biological Sciences Division of the Office of Naval Research has awarded a total of 122 research contracts. Of these, 30 support work in physiology, 15 in biochemistry, 25 in microbiology, 28 in medicine and dentistry, and 24 in biology.

* * *

In order to facilitate the exchange of information, the Psychology Branch of the Aero Medical Laboratory at Wright-Patterson Air Force Base is interested in discovering all individuals and organizations, both private and governmental, who are engaged in or interested in human engineering work. Such people are requested to send their names, the organization involved, its address, and particular areas of specialization or interest to the Psychology Branch, Aero Medical Laboratory, Directorate of Laboratories, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, Attention: F. H. Rohles. A list of these individuals and organizations will be compiled, and copies will be sent to each participant.

* * *

The Society of Protozoologists announces the publication of "A Catalog of Laboratory Strains of Free-living and Parasitic Protozoa." Sources from which protozoans may be obtained and directions for maintenance are included. The catalog will appear as an integral part of the February 1958 issue of the *Journal of Protozoology*. Reprints of the catalog will be sold at a nominal cost. Orders should be sent to Dr. D. M. Lilly, Treasurer, Society of Protozoologists, Department of Biology, St. John's University, Jamaica 32, New York.

* * *

The U.S. National Committee for the International Union of Biochemistry is now operating within the Division of Chemistry and Chemical Technology of the National Research Council. This eight-man committee represents the biochemists of the United States in matters relating to national participation in the International Union of Biochemistry and, specifically, makes nominations in the selection of U.S. delegates to the general assemblies and international congresses of the IUB. R. H. Barnes is the committee's chairman and S. W. Fox is secretary-treasurer.

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Harvey Mudd College has been awarded a grant from the Fund for the Advancement of Education to be used to survey experimental curricula in colleges of science and engineering throughout the United States. The award, which comes during the college's first year of operation, will enable members of the faculty to visit a number of colleges that are currently considering the revision of their curricula in the physical sciences and engineering.

* * *

Argonne National Laboratory has received authorization from the U.S. Atomic Energy Commission to proceed with design studies for a 12.5-Bev zero gradient proton synchrotron. Cost of the facility is estimated at $27 million, and the AEC has made available $1.5 million for detailed design work.

Scientists in the News

At its ninth session in Geneva on 19 December 1957, the Council of CERN, the European Organization for Nuclear Research, elected FRANCOIS DE ROSE of France as its president for 1958. In compliance with the terms of the CERN convention, which limits tenure of office to three successive years, De Rose succeeds Sir BEN LOCKSPEISER, who has presided over the governing body of CERN since October 1954. J. WILLEMS of Belgium and W. HEISENBERG of Germany have been elected vice presidents. They succeed DE ROSE and HOLTSMARK of Norway.

E. AMALDI of Italy has assumed the chairmanship of the Scientific Policy Committee, succeeding Heisenberg, and J. H. BANNIER of the Netherlands has succeeded Willems as chairman of the Finance Committee.

HERBERT L. ANDERSON has been named director of the University of Chicago's Enrico Fermi Institute for Nuclear Studies. He succeeds SAMUEL K. ALLISON, who has directed the institute since it was organized in 1946. Both men are professors in the department of physics and in the institute. Allison resigned his administrative duties to devote more time to his studies of low-energy particles.

ALBERT B. SABIN, professor of research pediatrics at the University of Cincinnati College of Medicine, has received the Phi Lambda gold medal and plaque for his contributions to the advancement of medical science. The award was made by the medical fraternity at its 50th annual convention dinner in the Waldorf-Astoria Hotel, New York. Sabin is known for his work in orally administered vaccine for the control of poliomyelitis and for his research in infectious diseases.

SOLOMON LEFSCHETZ, professor emeritus, department of mathematics, Princeton University, was recently elected corresponding member of the Academie des Sciences of Paris.

The U.S. Atomic Energy Commission has given its Distinguished Service Award, the highest honor it can bestow, to CHARLES L. DUNHAM, director of its Division of Biology and Medicine, and to SAMUEL R. SAPIRIE, manager of its Oak Ridge, Tenn., Operations Office.

FREDERICK D. ROSSINI, head of Carnegie Institute of Technology's department of chemistry and director of the school's Chemical and Petroleum Research Laboratory, was one of the principal speakers at the Indian Science Congress, which opened on 6 January in Madras. The Indian Science Congress Association is an organization that is similar to the AAAS.

JOHN TROAN, science editor of the *Pittsburgh* (Pa.) *Press*, has been named science writer for the Scripps-Howard Newspaper Alliance, with headquarters in Washington, and member of the Scripps-Howard editorial advisory board.

GEORGE P. FULTON, JR., chairman of the Boston University department of biology and specialist in small blood vessels, will be a visiting professor of physiology at the Stanford University School of Medicine in San Francisco, Calif., for 7 months beginning with the start of the second semester in February.

RICHARD R. KUDO, emeritus professor of zoology at the University of Illinois and since 1954 visiting professor of protozoology in the Institute of Microbiology at Rutgers University, will retire at the end of the current academic year.

SAUL GORDON and CLEMENT CAMPBELL have established a research and development consulting laboratory under the name of Gordon and Campbell, Consulting Chemists, at 12 Brookfield Way, Morristown, N.J. They are specializing in the application of thermoanalytical research techniques.

HAROLD J. LUTZ, Morris K. Jesup professor of silviculture and director of research in forest biology at Yale University, has received the Award for Biological Research of the Society of American Foresters. The award was given in recognition of Lutz's lifetime of work, and particularly for his studies, conducted in Alaska, of the effect of forest fires on vegetation. These studies, which occupied four summers beginning in 1949, were sponsored by the U.S. Forest Service, the Department of Agriculture, and the Bureau of Land Management of the U.S. Department of the Interior.

BABU N. PATEL, former director of research at E. Fougera and Company, has been appointed professor of pharmaceutical chemistry and chairman of the department of chemistry at the New England College of Pharmacy.

WILLIAM C. STEERE, dean of the Graduate Division and professor of biology, Stanford University, has been appointed director of the New York Botanical Garden. He will assume his new post on 15 July 1958. In the interim, DAVID D. KECK, assistant director and head curator, is serving as acting director. Director WILLIAM J. ROBBINS retired on 31 December at his own request. Steere has made extensive studies in the cytology and systematics of bryophytes and their geographic distribution and has engaged in field work in Puerto Rico, Colombia, Ecuador, and Alaska.

J. WILBERT EDGERTON, former executive director of the Alabama Association for Mental Health, has joined the staff of the U.S. Public Health Service's National Institute of Mental Health, which has assigned him to duty as mental health consultant in psychology in the Charlottesville, Va., regional office.

THOMAS E. ANDERSON, formerly deputy chief of the psychology section, U.S. Public Health Service Hospital, Lexington, Ky., has been transferred to NIMH as director of the School Mental Health Demonstration Project in Volusia County, Fla.

ROBERT S. SHELLOW has transferred to NIMH from the National Training School, Washington, D.C., and has been promoted to the grade of scientist and assigned to duty with the Mental Health Study Center, Langley Park, Md.

LAURENCE L. FROST, formerly with the National Institute of Neurological Diseases and Blindness, is now with NIMH as clinical psychologist in the Juvenile Court Clinic of the District of Columbia.

A. C. REDFIELD, senior oceanographer emeritus at the Woods Hole Oceanographic Institution, Woods Hole, Mass., will discuss "The Proportions of Things in the Sea" as a Sigma Xi national lecturer at a number of colleges and universities during January, February, and March.

LEONA E. TYLER, professor of psychology at the University of Oregon, is a visiting professor in the department of psychology at the University of California, Berkeley, for the present academic year.

WILLIAM J. GRACE and RICHARD J. KENNEDY have been appointed to the staff of St. Vincent's Hospital of the City of New York and to the faculty of New York University College of Medicine. Grace, who has served on the faculty of the Cornell University Medical College since 1946, has been named director of medicine and professor of clinical medicine; Kennedy, a member of the St. Vincent's attending staff since 1936, is now associate director of medicine and clinical professor of medicine.

HANS L. KORNBERG, member of the British Medical Research Council's cell metabolism unit in the department of biochemistry, University of Oxford, has been appointed research associate in bacteriology and immunology at Harvard University Medical School for the period February through June 1958.

CARLOS L. GONZÁLEZ, since 1954 assistant director of the Pan American Sanitary Bureau, Regional Office of the World Health Organization, has resigned, effective 31 March. González has been elected principal senator for his native state of Tachira, Republic of Venezuela, and will assume his legislative responsibilities in April.

Recent Deaths

LOUIS H. BARENBERG, Bronx, N.Y.; 71; clinical professor of pediatrics at New York Medical College; held an Award of Merit from the American Medical Association for original investigation on the "prevention of contagion in pediatrics wards with the use of human serum or plasma"; 18 Dec.

ALFRED W. DOLL, Oceanside, N.Y.; 54; assistant dean and professor of physics at Pratt Institute; 23 Dec.

JAMES C. DOWNS, Eugene, Ore.; 72; electrical and chemical engineer who discovered the electrolytic cell process; 18 Dec.

EDWIN A. GRIFFIN, Brooklyn, N.Y.; 70; otolaryngologist and past president of the Pan American Medical Association; 29 Dec.

W. L. HART, San Antonio, Tex.; 76; retired brigadier general, U.S. Army Medical Corps; helped to establish Brooke Army Hospital; head of the Southwestern Medical School, Dallas, Tex.; 22 Dec.

GEORGE W. HARTMAN, San Francisco, Calif.; 78; urologist and former secretary of the American Urological Association and former president and secretary of its western branch; 24 Dec.

TRACY B. KITTREDGE, Washington, D.C.; 66; retired captain, U.S. Naval Reserve; former assistant director of the Social Sciences Division of the Rockefeller Foundation; 22 Dec.

FLORENCE C. LEVY, New York, N.Y.; 65; bacteriologist with the nutrition board of the American Red Cross; 24 Dec.

HENRY W. McCANDLESS, Dunellen, N.J.; 91; former head of the special lamp division of Westinghouse Electric Corporation; aide to Lee de Forest in the development of the three-element electron tube; 24 Dec.

W. A. MURRILL, Gainesville, Fla.; 88; retired staff member of the New York Botanical Garden and former editor of *Mycologia*; 25 Dec.

FREDERICK L. OLMSTED, Malibu, Calif.; 87; landscape artist and city planner; member of various commissions concerned with the planning of the parks and government buildings in Washington, D.C.; consultant on many park projects; 25 Dec.

JOHN STUART, Washington, D.C.; 72; former aviation writer for the *New York Times*; 24 Dec.

CHARLES C. TREMBLEY, Daytona Beach, Fla.; 86; retired physician; for 35 years the director of the Trudeau Sanitarium at Saranac Lake, N.Y.; 20 Oct.

CHARLES A. WHEELER, Bridgeport, Conn.; 86; professor emeritus of mathematics at Storrs Agricultural College (now the University of Connecticut); 28 Dec.

Reports

Enzymatic Syntheses of Oligo- and Polysaccharides Containing D-Glucosamine

The synthesis of several oligosaccharides by carbohydrases has now been firmly established (*1–3*). Recently, Hestrin *et al.* (*4*) have demonstrated the formation of numerous glycosides by the action of levansucrase (from *Aerobacter levanicum*) on sucrose. Oligosaccharides, containing N-acetylglucosamine, are also reported to be formed by the action of *Lactobacillus bifidus* and preparations of mammalian tissue on lactose and N-acetylglucosamine (*5*). We have now shown that amino sugars act as acceptors in the transglycosylation reactions yielding oligo- and polysaccharides. This report (*6*) is a preliminary account of our observations (*7*).

By use of the method of estimation of glucose by notatin (*8*), it was found that D-glucosamine inhibits competitively the hydrolysis of sucrose by yeast invertase. The amino sugar, however, was found to have no inhibitory effect on the rate of synthesis of oligosaccharides; in fact, a slight stimulatory effect was observed. Further evidence was obtained by incubating invertase with a mixture of sucrose and glucose-U-C^{14}. The products were separated by paper chromatography, and their radioactivities were measured. When D-glucosamine was added to the mixture of sucrose, glucose-U-C^{14}, and invertase, larger quantities of labeled sucrose and oligosaccharides were formed (see *9*).

Aliquots of a mixture containing yeast invertase, sucrose-U-C^{14}, and D-glucosamine, after incubation at 25°C for varying periods of time (10 to 60 minutes) were subjected to electrophoresis on paper in 0.2*N* acetic acid. The filter paper strips were sprayed with ninhydrin. Two spots besides the one due to D-glucosamine were detected. The fructose content of these two spots was revealed by spraying them with the ketose-specific urea-HCl reagent. It was inferred from the relative mobilities of these amino sugar-oligosaccharides that one of them was a disaccharide and the other a trisaccharide.

The action of yeast lactase ("lactase-B") (*10*) on *o*-nitrophenyl-β-D-galactopyranoside was found to be inhibited by D-glucosamine, N-acetylglucosamine, and D-galactosamine. D-Galactosamine inhibits competitively, whereas D-glucosamine and N-acetylglucosamine inhibit noncompetitively.

Experiments in which galactose-U-C^{14} or glucose-U-C^{14} was used showed that either D-glucosamine or N-acetylglucosamine stimulates the synthesis of radioactive oligosaccharides and radioactive lactose formed by the action of lactase-B on a mixture of lactose and galactose-U-C^{14} or glucose-U-C^{14}. By electrophoretic and chromatographic techniques, four oligosaccharide components containing D-glucosamine and two oligosaccharide components containing N-acetylglucosamine were detected (see *2, 5, 11*).

Synthesis of levan from sucrose takes place in the presence of a cell-free extract of *Aerobacter aerogenes* grown adaptively on sucrose (see *4*). While several oligosaccharides are also formed, we have been unable to detect the formation of any significant quantity of free fructose or free glucose from sucrose. The presence of D-glucosamine or N-acetylglucosamine diminishes the amount of fructose in the isolated polysaccharide (see *12*). The polysaccharide synthesized by *Aerobacter aerogenes*, in the presence of sucrose and glucose, was hydrolyzed with 0.5 percent oxalic acid and was found to contain glucose as well as fructose. The polysaccharides synthesized by *Aerobacter aerogenes* in the presence of sucrose and D-glucosamine or N-acetylglucosamine were found to contain fructose, the respective amino sugar, and small amounts of glucose. Further evidence for the entry of the amino sugar into the polysaccharide was obtained by employing sucrose-U-C^{14} as substrate and estimating the specific activities of the labeled polysaccharides formed. The specific radioactivities of the polysaccharides synthesized in the presence of the amino sugars were found to be less than those of the polysaccharides synthesized in the absence of the amino sugars. Levansucrase from *Aerobacter aerogenes* was found to catalyze the formation of at least five detectable oligosaccharides containing glucosamine from a mixture of sucrose and D-glucosamine (Table 1).

Whenever D-glucosamine or N-acetylglucosamine was present in the reaction mixture containing *Aerobacter aerogenes* extract and sucrose, a stimulation of the rate of formation of free fructose and glucose, as well as of that of oligosaccharides and polysaccharide, was observed.

We have shown that, in the presence of yeast invertase or levan sucrase from *Aerobacter aerogenes*, several amino sugar-oligosaccharides are synthesized from sucrose and D-glucosamine. Moreover, polysaccharide containing D-glucosamine is formed by an extract of *Aerobacter aerogenes* from sucrose and D-glucosamine. Oligosaccharides containing D-glucosamine or N-acetylglucosamine are also formed by the action of yeast lactase on a mixture of lactase and amino sugar. It is therefore evident that the formation of heterogeneous mucopolysaccharide may be brought about by the transglycosylation mechanism. Such formation of oligo- and polysaccharides containing D-glucosamine may be studied quantitatively by the use of labeled sugars and electrophoretic separation. The fact that the amino

Table 1. Formation of oligosaccharides containing D-glucosamine by an extract of *Aerobacter aerogenes* in the presence of sucrose-U-C^{14} (0.18*M*) and D-glucosamine (0.3*M*). The reaction mixture contained *A. aerogenes* extract (0.1 ml), sucrose-U-C^{14} (total activity about 1 μc), citrate-phosphate buffer at *p*H 5.4 (0.1 ml), and D-glucosamine (brought to *p*H 5.4). The total volume was 0.5 ml. The mixture was incubated at 37°C under toluene. Ten-microliter aliquots were spotted on Whatman 3 MM paper. Electrophoresis was carried out at 500 v, 5 to 10 ma, for 3 hours in acetic acid buffer (0.2*N*).

Fraction after electrophoresis	Activity of fractions from 10 μl spot (count/min)	
	Incubation 60 min	Incubation 120 min
Origin	2946	2730
Highest polymer: III	217	331
II_1	52	139
II	70	200
I (probably disaccharide)	35	52

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

sugars inhibit the hydrolytic activities of yeast invertase and yeast lactase, but not their synthetic activities, may point to the existence of two separate enzymes or of two different glycosyl-enzyme intermediates, one concerned with the hydrolysis of the substrates into their monosaccharide constituents, the other with the synthesis of oligosaccharides.

S. SRINIVASAN
J. H. QUASTEL
McGill–Montreal General Hospital Research Institute, Montreal, Quebec

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25 September 1957

Increased Radioresistance through Heterosis

Strain differences in radiosensitivity of mice have been recognized for some time (*1–4*) even when the variables of age (*3, 5*), sex (*2, 6*), and dose rate (*7*), have been eliminated or controlled. These strain differences have not been explained, except that Brecker and Cronkite (*8*) tried to correlate the degree of injury to bone marrow with species differences.

Inbreeding has long been recognized as a condition leading to reduction in vigor of the species; the opposite practice—namely, outcrossing between fertile strains—has often resulted in first-generation hybrids which are, in certain respects, more vigorous than either of the parental stocks. This is known in genetics as "heterosis." When two divergent strains are crossed, only the first generation resulting therefrom tends to show the maximum beneficial effects in terms of size and vitality. When two diverse groups of heritable factors are brought together, homozygosity is reduced, and the more frequently deleterious recessive characters will be temporarily masked. The individual thus tends to exhibit vitality exceeding the vitality of either of the parent stocks.

Realizing that there are species and strain differences in radiosensitivity (or its reciprocal, radioresistance) and that even closely related and readily interbred mice do not necessarily have the same $LD_{50/30}$ value, we devised an experiment (*9*) to determine whether there might be any heterotic effect in hybrids between the CF_1 and C_{57} black/6 strains of mice. These two strains were inbred randomly for many generations prior to the production of the animals used in this experiment. At the same time a cross was made between C_{57} males and CF_1 females to produce the hybrid strain. The cross was made in this direction because it was found that C_{57} males were somewhat more aggressive than the CF_1 males, and mating resulted more frequently. It is not believed that the opposite cross would have produced F_1 genotypes which were any different.

A total of 485 mice were used in this experiment, divided into six categories of strain and sex, with a minimum of 64 mice in the smallest group and a maximum of 107 in the largest.

The radiation facilities used consisted of a Westinghouse Quadrocondex constant potential therapy x-ray machine at 210 kv (peak) and 15 ma, with 0.28-mm Cu and 0.50-mm Al filters, and at a distance of 40 cm from the target to the center of the body of the mouse. Seven mice were x-irradiated simultaneously in a plastic box in which they were free to move within the uniform field of exposure. The dose rate was 152.7 r/min.

It had previously been found that the $LD_{50/30}$ for the C_{57} black mice was a bit higher than that for the CF_1 white mice, and it has been known for some time that the males are more radiosensitive than are the females of the CF_1 strain (*2*). In order that the physical factors of x-irradiation might be the same for all mice of the same sex, it was decided to x-ray the males to 525 r and the females to 600 r when they were 2 months of age. It was hoped that this would give no 0 percent or 100 percent values in mortality and that all of the data would fall between these extremes. The data are all presented in Table 1.

Species differences in radiosensitivity, expressed in different $LD_{50/30}$ values, have never been explained. There is certainly no correlation with the phylogenetic or evolutionary relationships. Why, for instance, should the guinea pig be so sensitive, the hamster more resistant than man, and the chicken about twice as resistant as man? Nevertheless, the radiation-lethality data are highly reproducible and reliable and are used in radiobiological research for the testing of the effects of the so-called protective drugs and of numerous environmental variables.

Many of the factors which condition or alter radiosensitivity are known. Several of these are age, sex, metabolic or physical activity, or both, amount of oxygen in the environment, presence of infection, previous exposure to insult, and presence of certain so-called protective drugs. When all of these variables are equalized for the animals to be tested, we still find that the C_{57} black mice are more resistant to x-irradiation death than are the CF_1 white, even though they are so closely related that they can be freely interbred. The F_1 generation of a cross between these two strains is identical with the black parent in coat color, and yet the mice manifest survival values even better than that of either parent strain. This implies that the sum total of the effect of a large group of dominant characters coming from both parent strains to the heterozygous hybrids must give to these mice an improved radiotolerance. It would be impossible at this stage to point out those dominant characters which provide the increased radioresistance, or even the possible synergism involved. However, the data do substantiate the presumption that recessive mutants tend to be deleterious.

When one examines these data statistically (*10*) the increase in the female mice is seen to exceed the 5 percent level of probability, indicating that the hybrid female is very probably more radioresistant than either of its pure parent stocks. On the other hand, the relatively small increase in the male hybrids is not statistically significant (see Table 1). This might appear to weaken the thesis

Table 1. Heterosis (hybrid vigor) and radiosensitivity. F_1 mice were tested at 2 months of age. The numbers in parentheses represent the number of animals of the category which were irradiated; C_{57} mice are black, CF_1 mice are white, and the hybrids are black (dominant); χ^2 was determined between the hybrid and the C_{57} pure stocks which have the greater resistance.

Mice and radiation dose	Percentage survival				
	Pure	Pure	Hybrid	χ^2	P
F_1 generation	$C_{57} \times C_{57}$	$CF_1 \times CF_1$	$C_{57} \times CF_1$		
Females (+600 r)	20.8 (77)	8.6 (72)	36.5 (96)	5.055	< 0.05
Males (+525 r)	70.3 (64)	33.3 (69)	80.4 (107)	2.262	> 0.10

of hybrid vigor, or heterosis, until it is pointed out that the ovarian hormones are notably more potent than are the hormones of the testes with respect to radioprotection. It is even known that the male hormone is deleterious, with respect to radiation exposure (*2*), and combining the male hormone factors from two strains would tend, in all probability, to counteract any otherwise heterotic effect. In contrast with this, since the ovarian (female) hormones are beneficial (with respect to radiation resistance) one would logically expect that, added to other heterotic factors, the resulting hybrid females would be statistically more radioresistant than females of either parent stock. This is in fact our finding.

One conclusion is obvious—namely, that the combination of the haploid C_{57} black genome with the CF_1 white genome shows recessivity of the higher sensitivity of the latter, so that the hybrids exhibit radiosurvival in percentage values approximately three times that of the pure whites. Since, also, the male hybrids showed better tolerance than did the pure blacks (even though the finding is not statistically significant), one must admit to the probable influence of heterosis.

A recent paper by Uphoff (*11*) shows that F_1 marrow from a hybrid cross had more radioprotective value than did the marrow from either of the parental strains. The heterotic effect, therefore, probably pervades the entire hybrid.

The hybrid offspring obtained when two strains of mice are crossed (C_{57} and CF_1) have higher survival values than do either of the pure strains when exposed to whole-body $LD_{50/30}$ day x-rays. The increase is significant for the female offspring but not for the males. The results are explained in the case of the males on the basis of the combined and deleterious male tendencies being inadequate to counterbalance completely the beneficial effects of heterosis; the combined and beneficial female tendencies from the two strains, plus heterosis, resulted in statistically significant survival values for the F_1 females.

ROBERTS RUGH
JOAN WOLFF
Radiological Research Laboratory, Columbia University, New York

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3 October 1957

Induction of Neural Tissue in Ventral Explants from Frog Gastrulae by Carbon Dioxide Shock

If the speculation that the differentiation of cells depends in part upon cellular protein synthesis has any validity, then the possibility exists that the culture of ventral mesoderm and ectoderm of the early *Rana pipiens* gastrula (stage 10) under conditions which might accelerate protein synthesis conceivably might also effect the type of cell differentiation. In the vast majority of control experiments, the ventral parts of the frog gastrula showed differentiations of mesenchyme, epidermal and blood cells, and also oral suckers, when cultured at 17°C in small stender dishes containing about 10 ml of a buffered saline solution (Niu-Twitty solution) (*1*) for periods of 6 to 14 days. Neural, muscular, nephric, or chordal tissues appear in less than 2 percent of the cultures. At the end of the culture period the explants were fixed in Bouin's fixative, sectioned at 10 μ, and stained with hematoxylin eosin.

In the various experimental series of cultures, the ventral explants were cultured at higher temperatures, in various nutrient media and were also subjected to brief shocks with alkaline and acid media. For the control and experimental series a total of 230 cultures, which included 1900 explanted tissues, were made. The aim of these experiments was to increase the level of metabolism, or of available nutrient, and thus possibly to accelerate the synthesis of cytoplasmic proteins and determine the effect upon differentiation (*2*).

Possibly the most direct means of raising the rate of metabolism of the ventral explants is to culture them at higher temperatures. Although Gilchrist (*3*), Huxley (*4*), and Margen and Schechtman (*5*) applied local high-temperature stimuli to ventral regions of whole eggs without altering morphogenesis, this method has the disadvantage that it may not overcome any dominance factors that might emanate from the differentiating dorsal structures. This would not be a problem in culturing the isolated ventral tissues at the higher temperatures. When gastrula ventral mesoderm-ectoderm was cultured at temperatures of 28, 30, and 33°C for 3 to 4 days and then at 17°C for 6 more days, differentiation was merely equivalent to that of the control cultures. Thus it appears that higher temperatures alone, although they certainly raise the level of respiration, cannot alter the prospective fate of these tissues. However, it is known from experiments in vitro (*6*) that higher temperatures alone cannot increase the extent of solubilization of yolk platelets.

Another possible means of attempting to accelerate protein synthesis in the explants is to supply the cells with nutrient in the culture medium and thus attempt to bypass the yolk as the nutrient source. To this end, bits of ventral mesoderm-ectoderm from early gastrulae were cultured in various concentrations of a nutrient medium containing all the essential amino acids, most of the water-soluble vitamins, glucose, and each of the nucleotides; in saline extracts from hatched larvae, adult frog hearts, brains, and muscle; and also in livetin (the water-soluble yolk protein) dissolved in a *p*H 5.7 acetate buffer-saline medium. None of these series of explants showed greater specialization than the controls cultured in Niu-Twitty solution. The combination of added nutrient and culture at higher temperatures also failed to induce the formation of dorsal tissues in a significant number of cases.

Acid and alkaline shocks have been utilized in eliciting the formation of neural tissue in isolated ventral tissues of urodele gastrulae (*7*), but such experiments have not yet been successfully carried out with the frog embryo. Holtfreter (*8*) has demonstrated that a *p*H below 4.0 and above 9.6 partially solubilizes yolk platelets, and I have put forth the idea that solubilization of protein, including ribonucleoprotein, from the yolk platelets and the initiation of embryonic differentiation may be causally related (*6*). In order to ascertain whether inductions could be obtained in the anurans with low and high *p*H, ventral explants were exposed to 0.02 percent NH_4OH in tap water (*p*H 11.0) for 3 to 6 minutes, washed several times in sterile saline, and cultured for 6 to 12 days. The acid shocks were carried out by bubbling CO_2 into the nonbuffered "A" part of the culture medium until the *p*H was 3.7, and explants were left in this acidified medium for periods ranging from 10 minutes to 1 hour and then cultured in the normal saline medium for 12 days. Most of the CO_2 shocks were for 10 or 20 minutes since longer shocks sometimes killed the explants.

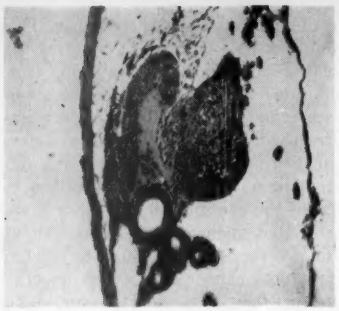

Fig. 1. Neural and nephric differentiation in a ventral explant that received a CO_2 shock.

The use of CO_2 is particularly advantageous because this gas can readily penetrate into the cells and because it does not disaggregate the cells or cause the marked cytolysis that followed the alkaline shock treatments. Modification of the "A" part of the culture medium with a 0.005*M* acetate buffer to a *p*H of 3.7 was not effective in inducing dorsal tissues.

No dorsal structures were observed in the explants that received alkaline shocks, but neuroid tissue and parts of the brain were frequently noted in explants that had received CO_2 shocks. An example of such differentiation is illustrated in Fig. 1. Less frequently, muscle, nephric tubules, and notochord were present in the explants. Of the ventral tissues that received CO_2 (*p*H 3.7) shocks, 50 percent showed neuroid tissue, 40 percent had well-defined brain vesicles, while in 10 percent of the cases no dorsal structures were present. The latter percentage is far above that of such tissues appearing in the other types of culture. One possible interpretation of the mechanism of CO_2 induction is that the acid shock released soluble protein and ribonucleoprotein from the yolk platelets (*6, 8*) and that this initiated the synthesis of cytoplasmic protein and subsequent differentiation of the dorsal tissues.

REED A. FLICKINGER

Department of Zoology,
University of California, Los Angeles

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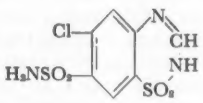
† November 1957

Electrolyte Excretion as Influenced by Chlorothiazide

In 1953 we reported that *p*-carboxybenzenesulfonamide produced (i) both natriuresis and chloruresis in dogs and (ii) that there was a causal relationship between the (plasma) concentration of drug presented to the kidney and the saluretic effect (*1*). These two attributes of that compound appeared to be inconsistent with the more classical concepts of the nephrotropic action of a carbonic anhydrase inhibitor (*2*). That agent was not sufficiently potent to warrant extended clinical study.

This premonitory indication that saluresis might be a clinically important attribute of a potent carbonic anhydrase inhibitor that fulfilled certain specific pharmacodynamic criteria has influenced our studies of renal electrolytes. In addition, the secondary attributes for an essentially specific nephrotropic agent of this category have been considered by us to include good absorption from the gastrointestinal tract, a volume of distribution essentially limited to extracellular fluid, a high concentration ratio of the compound in nephron/plasma, and high carbonic anhydrase inhibitor activity (*1*).

In the course of this study, it was found that an unusual heterocyclic acid increased substantially the excretion of sodium and chloride by the dog. This agent was synthesized by Novello and Sprague (*3*), who identified it as 6-chloro-7-sulfamyl-1,2,4-benzothiadiazine-1,1-dioxide and assigned to it the following structure:



The compound is referred to herein as chlorothiazide or Diuril (*4*).

Qualitatively, at equal dosages and under similar experimental conditions, chlorothiazide induces changes in electrolyte excretion that more nearly resemble those known to be caused by the organomercurial diuretic agents than the response generally considered to attend the administration of a carbonic anhydrase inhibitor. Under reasonably normal conditions of acid-base balance, the effect of chlorothiazide is to increase the excretion of sodium and chloride preponderantly. The excretion of potassium and bicarbonate is increased slightly, if at all. However, the effect of the drug on the ratio of sodium to chloride excreted per unit time varies according to the state of electrolyte balance of the dog.

In the two experiments summarized in Table 1, the dogs were pretreated on three successive days with moderate amounts (3.0 g/day) of $NaHCO_3$ or NH_4Cl, the last dose being administered just prior to the control phase of the test. When the animal was pretreated with $NaHCO_3$, chlorothiazide caused a substantial increase in chloride excretion that was quite inadequate to cover the profound increase in sodium elimination. The increase in urinary *p*H reflects a substantial increase in bicarbonate excretion in the drug phase which more elaborate renal clearance experiments have demonstrated. In the NH_4Cl experiment, chlorothiazide caused a marked increase in chloride excretion which was essentially equivalent to the amount of sodium eliminated. Under the conditions of this experiment, the excretion of bicarbonate is negligible and the effect on potassium elimination or urinary *p*H is not impressive.

The oral or parenteral administration of chlorothiazide to dogs made edematous by an excessive daily intake of a mineralocorticoid, NaCl, KCl, and water resulted in a prompt loss of fluid with reduction of weight to normal only as long as the drug was administered (Fig. 1). During the 100-day test, the apparently normal dog received 6 mg of 9α-fluorohydrocortisone, 2 g of NaCl per kilogram, and 150 mg of KCl plus 1000 ml water orally per day in addition to the Na and K contained in its diet. During the coadministration of 5 mg/kg of chlorothiazide orally twice daily from the 23rd through the 34th day, body weight returned to control value. When the drug was withdrawn, the dog promptly gained weight. After the single injection of the saluretic agent on the 78th day, the dog lost 0.7 kg of body weight within 24 hours. The attendant decrease in weight was maintained when the drug was administered orally until chlorothiazide therapy (5 mg/kg twice daily) was withdrawn on the 88th day. Thereafter, the dog began to gain weight under influence of the steroid. The ability of this agent to counteract the sodium and fluid retention induced by steroids has been confirmed by the repetition of this type of experiment in other dogs and by conventional renal clearance experiments in this species.

Chlorothiazide is an orally active saluretic (or diuretic) agent. Its predominant effect is to increase the excretion of sodium and chloride. Secondarily, it

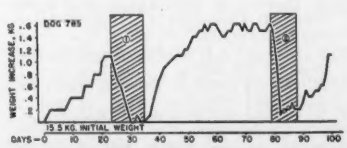


Fig. 1. Reversal by chlorothiazide of weight gain induced by the injection of 9α-fluorohydrocortisone and a high salt intake.

Table 1. Effect of chlorothiazide venoclysis (2.5 mg/kg prime plus 3.0 mg/kg hr) on the renal elimination of electrolytes in dogs pretreated for 3 days with 3 g of $NaHCO_3$ or NH_4Cl. Triplicate 10-minute clearances were measured in "control" and "drug" phases. Data are tabulated as: average "control" value/average "drug" value.

Na		K	Cl^-	Urinary
Amt (μeq/min)	Reabsorption (%)	(μeq/min)	(μeq/min)	pH
Pretreatment with $NaHCO_3$				
143/400	98.9/95.8	26/41	17/131	7.4/7.9
Pretreatment with NH_4Cl				
8/273	99.8/95.1	9/27	15/280	5.7/5.8

causes an increased excretion of retained fluid. In this respect, it resembles the organomercurial diuretic agents from which it differs in structure and apparent mode of action. The chloruresis distinguishes this agent from carbonic anhydrase inhibitors that cause a predominant increase in bicarbonate rather than chloride excretion when administered to the dog and to man.

KARL H. BEYER, JR., JOHN E. BAER, HORACE F. RUSSO, RONALD NOLL
Merck Institute for Therapeutic Research, West Point, Pennsylvania

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4. Chlorothiazide is the nonproprietary name for 6-chloro-7-sulfamyl-1,2,4-benzothiadiazine-1,1-dioxide. Diuril is the trademark of Merck & Co., Inc. for this compound.

18 October 1957

Marine Fungus Requiring Vitamin B_{12}

Thraustochytrium globosum, an obligately marine fungus (Phycomycete) isolated from littoral sea water, has been found to require vitamin B_{12} for growth in a defined medium (*1*). This is the first instance of a fungus known to require an exogenous supply of vitamin B_{12}. The finding is therefore of interest to comparative biochemists because it places the fungi among the groups of organisms (bacteria, algae, animals) in which this vitamin is an essential metabolite, rather than with the higher plants which neither require nor produce vitamin B_{12} (*2*). It is further of considerable ecological interest: the B_{12} requirement of many members of the phytoplankton (*2*, *3*) and the production of vitamin B_{12} by various marine bacteria (*4*) have provided evidence for the occurrence of this metabolite in ocean water.

Investigation of the determinative importance of vitamin B_{12} in marine ecology has been hampered by difficulties in assaying sea water. Extraction procedures necessary for assays with the usual microorganisms are time consuming and result in the loss of 5 to 25 percent of the vitamin (*5*). The best direct assay so far described (using the marine Chrysophyte, *Monochrysis lutheri*) requires 3 to 4 weeks and includes possible responses to pseudovitamin B_{12} and factor A (*6*). There are obvious advantages in assay organisms requiring shorter incubation periods. It would also be desirable to have available assay organisms providing a range of specificities suitable for distinguishing the biologically active forms of the vitamin. Since *Thraustochytrium globosum* requires an incubation period of only 9 to 14 days, it is presented as a possible assay organism. This fungus also responds to vitamin $B_{12_{III}}$, but not to pseudovitamin B_{12}, factors A, B, G, or H, or thymidine (in the presence or absence of 1 mg/100 ml each of adenine, guanine, and uracil). Determination of the effect of the presence of methionine on the B_{12} requirement is complicated by the toxicity of this amino acid.

The basal medium used in the determination of the B_{12} requirement of this fungus is given in Table 1. Fresh glass-distilled water was used in the preparation of all solutions and media. The *p*H of the medium (at twice the final concentration) was adjusted to 7.5 with NaOH before the addition of agar. Glucose and $NaHCO_3$ were added aseptically after autoclaving. Experimental media were dispensed in 10-ml lots in 25-ml glass-capped erlenmeyer flasks. After sterilization and inoculation, the flasks were sealed between Pyrex kitchen trays with transparent cellulose tape and incubated for 10 days at 15°C. Optical density, as determined with a Klett-Summerson photoelectric colorimeter with No. 42 filter, was used as a measure of growth.

Inocula depleted of vitamin B_{12} were prepared by transferring 0.2 ml from cultures grown with 5 μg of vitamin B_{12} per milliliter to tubes containing 5 ml of basal medium. These inocula were incubated for 1 to 2 weeks at 15°C, to a population density of 1.0 to 1.7×10^5 cells per milliliter. One drop from such a culture was used to inoculate each experimental flask.

The growth response to increasing concentrations of vitamin B_{12} is illustrated in Fig. 1. The points on this graph represent the average of three experiments, each performed in duplicate. In individual experiments, variation between duplicate flasks seldom exceeded the error of the colorimeter; the greatest differences between experiments ranged from 9 Klett units (5 μμg of vitamin B_{12} per milliliter) to 21 Klett units (100 μμg/ml). The greater variation at higher vitamin concentration may reflect the fact that these cultures are still in the exponential phase of growth at 10 days. Growth in the presence of 100 μμg of vitamin B_{12} per milliliter reaches the stationary phase at 14 days. Since the Klett reading given by cultures grown with lower (for example, 10 μμg/ml) concentrations of vitamin B_{12} remain constant from the 8th to at least the 14th day, it is feasible to use a longer incubation period when greater precision at higher vitamin levels is desired. The sensitivity of the response is the same as that of the more prominent fresh-water assay organisms, *Lactobacillus leichmannii*, *Euglena gracilis*, and *Ochromonas malhamensis*.

Table 1. Basal medium for demonstrating the B_{12} requirement of *Thraustochytrium globosum*.

Nutrient	Amount
NaCl	2.5 %
KCl	0.1 %
$MgSO_4 \cdot 7H_2O$	0.5 %
KH_2PO_4	0.01 %
$CaCO_3$ (in acid)	0.02 %
Na_2EDTA	0.05 %
$(NH_4)_2SO_4$	0.02 %
Zn (as sulfate)	1.0 mg/100 ml
Mn (as sulfate)	1.0 mg/100 ml
Fe (as sulfate)	0.2 mg/100 ml
Cu (as sulfate)	0.002 mg/100 ml
Co (as sulfate)	0.02 mg/100 ml
B (as boric acid)	0.02 mg/100 ml
Mo (as sodium molybdate)	0.02 mg/100 ml
NaH · glutamate	0.05 %
L-Lysine	1.0 mg/100 ml
Thiamine · HCl	20.0 μg/100 ml
Glucose	0.1 %
$NaHCO_3$	0.02 %
Agar	0.1 %

The practicability of assaying vitamin

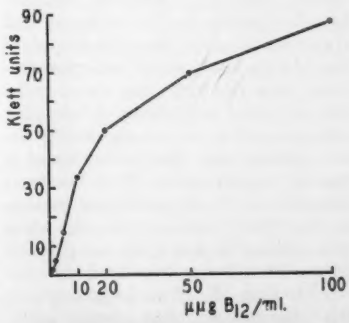

Fig. 1. Growth of *Thraustochytrium globosum* in the presence of various concentrations of vitamin B_{12}.

B_{12} in sea water was tested with water collected in July 1957 from two stations in Long Island Sound and frozen within 5 hours after collection. For the assay, the sea-water samples were enriched with glucose, glutamate, lysine, thiamine, and agar at the level of the basal medium. Five- and 2.5-ml portions of each sample were diluted with full-strength basal medium (without bicarbonate) to a final volume of 10 ml. Undiluted samples were inhibitory to *Thraustochytrium globosum* in the presence or absence of added vitamin B_{12}. Consistent results and satisfactory recovery of added vitamin B_{12} (5 mμg/ml) were obtained with one sample at both dilutions; with the other, only at the greater dilution. Both samples assayed 16 to 20 mμg of vitamin B_{12} per liter—a level somewhat higher than that found for unfiltered ocean water at other locations and at various seasons by Cowey (*5*) and by Droop (*6*) (0.2 to 4.0 mμg/lit and 5 to 10 mμg/lit, respectively).

ELIZABETH J. ADAIR
HELEN S. VISHNIAC
Department of Microbiology, Yale University, New Haven, Connecticut

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4 November 1957

Propagation of Infectious Canine Hepatitis Virus in Porcine Kidney Tissue Culture

Infectious canine hepatitis virus has generally been considered to be a host-specific agent (*1*). Numerous attempts have been made, in this laboratory and elsewhere, to adapt this virus to embryonated eggs, mice, rabbits, and other animals, with essentially negative results. The successful propagation of infectious canine hepatitis virus in dog-kidney tissue cultures with the production of a typical cytopathogenic effect has been reported (*2, 3*). By continuous passage in dog-kidney tissue culture, the virus was modified so that it did not produce disease when it was inoculated into susceptible dogs (*3*). Previous attempts in this laboratory to adapt virulent infectious canine hepatitis virus to pig-kidney explants were unsuccessful. This report shows that the virus can be successfully propagated in pig kidney epithelial cells after a series of passages in dog-kidney tissue cultures.

Tissue cultures were prepared from the kidney cortex of pigs of between 2 and 12 weeks of age by a trypsin digest method in which 0.33 percent trypsin was used. Two nutrient media were employed: (i) 0.5 percent solution of lactalbumin hydrolyzate in Earle's balanced salt solution, fortified with 10 percent inactivated horse or bovine serum (ELS medium); (ii) medium No. 199 (Parker) without serum. Each medium contained penicillin and streptomycin. Initial attempts to adapt infectious canine hepatitis virus to trypsinized-pig-kidney tissue cultures were made with virulent virus. From portions of liver from two dogs killed during the acute phase of infection, 20-percent suspensions in physiological saline were made, and the supernatants of these were inoculated into culture tubes containing ELS medium. Additional cultures were inoculated, in the same manner, with tissue culture fluid from the 14th dog-kidney tissue culture passage of infectious canine hepatitis virus. The cultures, incubated at 35°C, were observed for 7 days, after which time the fluids from each group of tubes were harvested and passed into additional tubes. Subpassages of each group of cultures were made three times, at 7-day intervals. At that time, the tissue culture fluids were inoculated into trypsinized-dog-kidney roller tubes, to test for the presence of virus. No virus could be detected.

Further efforts at adaptation were made with modified virus which had undergone 134 passages in dog-kidney cultures. Several pig-kidney tissue cultures in tubes containing ELS medium were inoculated in a manner similar to that described above, and subpassages were prepared. Commencing with the fifth tissue culture passage, a portion of the cells exhibited a cytopathogenic effect that resembled, to some degree, the changes previously observed in dog-kidney tissue cultures. This effect continued to occur, in an erratic manner, through the tenth passage. Beginning with the tenth passage, the nutrient medium was changed to No. 199. Thereafter, a complete cytologic change developed in the cells 3 to 6 days after inoculation and occurred regularly through 28 additional passages. The titer of the tenth pig-kidney passage was $10^{5.0}$, as was demonstrated by titrations in dog-kidney tissue culture. Titrations at intervals through the 38th passage ranged from $10^{4.5}$ to $10^{5.5}$. The affected cells became swollen, rounded-up, and highly refractile. Epithelial sheets broke up, and the cells formed small, grapelike clusters.

Serum neutralization tests to identify the cytopathogenic agent in pig-kidney tissue were performed at various passage levels. Infected tissue culture fluid prepared in tenfold dilutions was mixed with an equal amount of known infective-canine-hepatitis-positive canine antiserum. These mixtures were incubated for 2 hours in a 37°C water bath and inoculated, in 0.2-ml amounts, into each of several pig- and dog-kidney cultures. Up to 100,000 tissue culture infectious doses of virus were neutralized both in pig and dog cultures by the positive serum, while the usual cytopathogenic effect occurred in control cultures that contained the normal serum.

Tests were made in dogs to provide additional evidence that the cytopathogenic agent propagated in pig-kidney tissue culture was infectious canine hepatitis virus. Fourteen infectious-canine-hepatitis-susceptible dogs were used. Eight were inoculated subcutaneously with 19th-passage, and six with 34th-passage, material. Daily temperature recordings and observations for other signs of illness were made for 3 weeks, following which the animals were challenged with known virulent virus. No signs of illness were observed in the dogs inoculated with pig-adapted virus, and none of the dogs responded to challenge. Preinoculation serums were found to be negative (by a serum-neutralization test employing known infectious canine hepatitis virus that had been grown in dog-kidney culture); all dogs had developed neutralizing antibody titers of from 100 to 3200 three weeks later. The development of specific antibodies in the dogs further demonstrates that the cytopathogenic agent is infectious canine hepatitis virus. The lack of illness in the inoculated dogs indicates that the virus is of modified virulence and could be used for development of a vaccine.

JERRELL B. EMERY
CHARLES J. YORK
Research Division, Pitman-Moore Company, Indianapolis, Indiana

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5 August 1957

Action of Hydrocortisone on Respiration and Aerobic Glycolysis of Cultured Cells

In previous reports, inhibition of growth of fibroblasts by a single high dose of hydrocortisone was demonstrated (*1*). Cells derived from a single fibroblast, which had been isolated from a culture of normal subcutaneous tissue of the mouse, Earle's strain L, have been

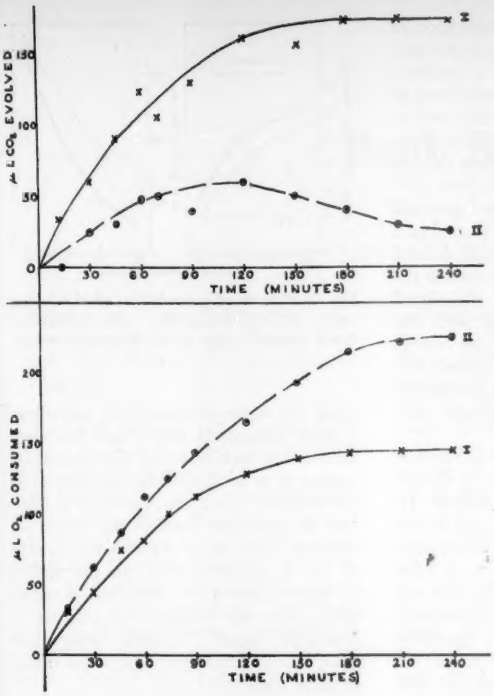

Fig. 1. (Top) Aerobic glycolysis: curve I, 150 μg of hydrocortisone per milliliter; curve II, control. (Bottom) Respiration: curve I, 150 μg of hydrocortisone per milliliter; curve II, control.

found to be highly responsive to the growth-inhibiting action of hydrocortisone and were chosen for the present experiments (*2*). Growth measurements were carried out by the method of enumeration of cell nuclei (*3*). In 11 experiments the average growth inhibition caused by a single dose of hydrocortisone in a concentration of 125 μg/ml was found to be 40 percent. In order to obtain more information concerning the mechanism of the direct action of hydrocortisone on cells, its action on respiration and aerobic glycolysis of cultured cells has been investigated.

Two series of experiments were carried out. In the first series, the cells from eight T-60 flasks, each containing about 15×10^6 cells growing in a medium consisting of embryo extract, horse serum, and Earle's balanced salt solution in proportions of 20:40:40, were scraped from the glass, pooled, and centrifuged; the residue was suspended in 25 ml of fresh medium containing phenol red as a *p*H indicator (*p*H approximately 7.4). Three milliliters of the cell suspension was put into each of the eight Warburg flasks, and the remaining 1 ml was used for enumeration of cell nuclei. To four of the Warburg flasks, 0.50 ml of Earle's salt solution containing hydrocortisone in a concentration of 125 μg/ml was added, and to four control flasks, 0.50 ml of Earle's solution, without hydrocortisone. Since the hydrocortisone stock solution contained 50 percent ethanol, ethanol in equal final dilution was added to the control vessels. Control and experimental flasks in most cases were in duplicate: two control flasks containing 0.20 ml of 15 percent KOH in the central well, for measurement of oxygen uptake, and two control flasks containing 0.20 ml of H_2O in the central well, for measurement of aerobic glycolysis; two flasks for measurement of oxygen uptake in the presence of hydrocortisone, and two for measurement of aerobic glycolysis in the presence of hydrocortisone. The reading obtained from the flasks with H_2O in the central well is the resultant of both the consumption of O_2 (as shown on the flasks with alkali) and the liberation of CO_2. The aerobic glycolysis is thus obtained by taking the difference between the readings on the flasks with and without alkali. The "direct method" (*4*) was employed because, for comparison of values obtained in the presence and in the absence of hydrocortisone, the effect, if any, of CO_2 on the rate of respiration was assumed to be insignificant.

In the second group of experiments, to four of eight T-60 flasks, each containing equal numbers of cells, hydrocortisone in a concentration of about 1.50 μg/ml was added at the time of explanation. After 72 hours the same concentration of hydrocortisone was added to each of the four flasks (without removal of the medium), plus 2.50 ml of new medium. After another 24 hours (96 hours from the beginning of the experiment), hydrocortisone in the same final concentration was again added to the cell suspensions of the four Warburg flasks in new medium, before they were put in the manometric bath. Each Warburg flask contained in its main compartment equal numbers of cells suspended in 3 ml of new medium, to which 0.50 ml of Earle's salt solution containing hydrocortisone was added. Four control vessels were treated in the same way, but without hydrocortisone. In four experiments, in which only respiration was measured, cholesterol, cortisone acetate, and the mineralocorticoid deoxycorticosterone in the same concentration, were also used as controls.

In the first group of experiments, a single dose of hydrocortisone, when added to the cell suspension in Warburg flasks, caused inhibition of respiration which, in eight out of nine experiments, was coupled with significant increase of aerobic glycolysis. Hydrocortisone in the same concentration, when added in a single dose to cultured cells, causes growth inhibition averaging 40 percent for 125 μg/ml, as determined by enumeration of cell nuclei. In this group of experiments, 40 μg/ml appeared to be below the minimal concentration of hydrocortisone necessary for obtaining reproducible inhibition of respiration by a single dose added immediately before the experiment (Fig. 1). Accordingly, concentrations of about 40 μg/ml in a single dose showed no significant growth inhibition of cultured cells.

In the second group of experiments, hydrocortisone added to the cultures at 96 hours, at 24 hours, and immediately before the manometric experiment, caused significant stimulation of respiration and of aerobic glycolysis.

It appears that the inhibition of growth and the inhibition of respiration by the same high concentration of hydrocortisone are connected with one another.

In the first group of experiments, the release of glycolysis may be due to the inhibition of respiration, in accordance with the "Pasteur effect," while in the second group of experiments, in which low concentrations of hydrocortisone were used, the stimulation of both respiration and aerobic glycolysis undoubtedly represents a specific action of the glucocorticoid hydrocortisone. The mineralocorticoid deoxycorticosterone did not have the same effect as hydrocortisone, and cholesterol was without effect.

While hormonal effects on anaerobic glycolysis have been demonstrated recently in certain tumor tissues (*5*), the present studies emphasize the possibility of demonstrating reproducible hormonal effects in aerobic glycolytic systems. The latter may reflect more truly the conditions prevailing in the organism.

The relationship between the high aerobic glycolysis of hydrocortisone-treated cells and the decrease of "resistance" to tumor grafting in hydro-

cortisone-treated animals can at the present time be only a matter of conjecture.

HENRY GROSSFELD
Departments of Medicine and Orthopedic Surgery, College of Physicians and Surgeons, Columbia University, and Edward Daniels Faulkner Arthritis Clinic, Presbyterian Hospital, New York

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11 October 1957

Effects of Stimulation of Brain Stem on Tachistoscopic Perception

This report concerns part of a study (*1*) conducted on rhesus monkeys to investigate the effects of electrical stimulation of different sites in the brain on tachistoscopic perception.

For this investigation the animals were first trained to discriminate between stereometric objects presented in pairs, by placing food reward under one of the objects of each pair. After this preliminary training without restriction of exposure duration, each animal was subjected to several series of trials at different exposures; the number of correct responses was noted, and the reaction time was automatically measured. The testing apparatus was a modification of that used by Harlow, which for our purposes was transformed into a tachistoscope (Fig. 1). Its main feature was an argon-mercury bulb which was used to flash briefly a light of controllable duration and constant intensity upon the objects. The pairs of white objects (for example, a cone and a 12-sided pyramid of similar proportions) were placed in a dark field in front of the animal. A brief acoustic signal preceded by 2 seconds the illumination of the objects; this signal was in no case concomitant with the visual stimulus. Selection of the correct member of each pair was always followed by a food reward. The position of the correct member was changed randomly from trial to trial.

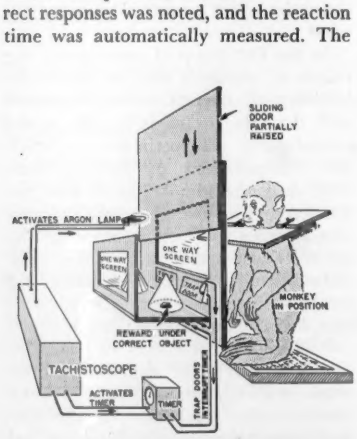

Fig. 1. Testing apparatus for visual discrimination. The monkey is shown in one of the plastic collars (schematically represented) by which the animals were permanently held to protect the electrode mount from their hands and to restrict them partially for performing the experimental task.

Electrodes were implanted in the animals' brains so that the effects of electrical stimulation could be studied. To date, six animals have been used in the investigation. The electrode placements were histologically verified. As a rule, currents were always used that did not cause any apparent effect on the normal behavior of the awake animal, regardless of the placement of the electrodes. A biphasic square wave current, of 300 cy/sec and intensities between 100 and 300 μa, was used as a norm. Each animal was used as its own control. In the experimental series, the electrical stimulation was applied during each trial period, starting 2 seconds in advance of the flash and persisting until the animal had made its choice.

Stimulation of the core of the brain stem at the level of the mesencephalon consistently increased the animals' efficiency at discrimination, as indicated by significantly higher percentages of correct responses and shorter reaction times as compared with the controls (Fig. 2). Stimulation through the same electrodes with intensities higher than the threshold for the elicitation of observable motor effects, such as generalized muscular jerks (startle reaction), eye movements, pupillary oscillations, vocalization, and so forth, had a deleterious effect on the performance of the animals, as indicated by the diminution of correct responses at all exposure durations and prolongation of reaction time. These effects were consistent and reproducible from animal to animal.

The same areas which upon mild stimulation facilitated tachistoscopic discrimination have previously been shown to evoke electroencephalographic and behavioral arousal in the sleeping or relaxed animal (*2, 3*). These areas are in the rostral part of the brain stem activating system, which is mostly composed of the reticular formation of the midbrain tegmentum. Evoked potentials of long latency to sensory stimuli are also picked up in these areas (*4*). This was verified in the present investigation, by using the same electrodes for recording.

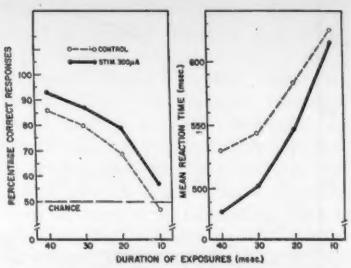

Fig. 2. Effects of stimulation of the brain stem on tachistoscopic discrimination. Each plotted point is based on 100 trials.

Both perceptual and motor processes involved in tachistoscopic discrimination appear to be facilitated by stimulation of the reticular activating system. It is difficult to determine whether the effects on reaction time are a direct consequence of the facilitatory effect on perception or independent of it. However, it seems likely that the reticular facilitation is primarily upon "central integrative time," rather than upon peripheral transmission time.

These findings give support to the hypothesis that the reticular activating system, whose primary role has been demonstrated to be that of central mediator for the achievement and maintenance of wakefulness by means of activation of the cortex, extends its function to the alert state as a further manifestation of the same physiological role, subserving basic attentive behavior. Its different degrees of excitation underlie the gradation of this function from deep sleep to extreme alertness. Excitation of this brain stem system induces general activity of the cortex (arousal), presumably facilitating its receptivity to the sensory impulses ascending over the classic sensory paths. The facilitation of tachistoscopic discrimination by electrical stimulation of the same system may be considered as an example of such an effect on visual perception.

JOAQUIN M. FUSTER*
Department of Psychiatry, School of Medicine, University of California, Los Angeles

References and Notes

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2. G. Moruzzi and H. W. Magoun, *Electroencephalog. and Clin. Neurophysiol.* 1, 455 (1949).
3. J. P. Segundo, R. Arana, J. D. French, *J. Neurosurg.* 6, 601 (1955).
4. J. D. French, M. Verzeano, H. W. Magoun, *A.M.A. Arch. Neurol. Psychiat.* 69, 505 (1953).

* Del Amo fellow.

25 November 1957

Book Reviews

Principles of Plant Pathology. E. C. Stakman and J. George Harrar. Ronald, New York, 1957. xi + 581 pp. Illus. $8.

To many persons, plant pathology is an art. To Stakman and Harrar, plant pathology is a science.

In America the *art* of plant pathology is flourishing. Plant diseases are serious matters to farmers and to all who grow plants for pleasure or profit, and they have emphasized the pragmatic programs of plant pathology. American plant pathologists have responded so well to these pressures and have built up the art so well that they are sometimes envied by their colleagues abroad.

As for the *science* of plant pathology in America, the case is very different. As the readers of this journal well know, such situations are evident in other sciences as well. Plant pathology is not alone.

It is high time that someone published a book on the science of plant pathology in America, and Stakman and Harrar have done so. Prior to this we have had books galore on such subjects as diseases of citrus or pathology in forest practice, and we have had books on practical control methods. Other books have been aimed somewhat more closely than these in the direction of scientific plant pathology. They have dealt with the microbial agents of disease. A typical chapter heading would be "Diseases caused by Ascomycetes." This approach to the subject attains scientific status by default: It is not immediately practical, therefore, it must be scientific. Actually, these books, like the others, simply give an encyclopedic treatment of individual diseases. They merely slice the subject at a different angle. Treatment of theory in either pattern is "purely coincidental."

Stakman and Harrar have cast all that aside. They are concerned with plant disease as a conceptual scheme, not as a series of diseases to be fought. Theirs is not a book on diagnosis or control, on mycology or virology or nematology. They have dared to consider theory their first order of business—to speculate on the nature of things. They have, for example, attempted to give some explanation of the reasons why spore-bearing structures in fungi are shaped as they are; why fungi must penetrate tissues in the way that they do. They remark, characteristically, "A disease . . . is essentially a process—a stream of events that can be affected anywhere along its course by other streams of events." This is thoughtful writing about a dynamic subject.

I think they have weakened their case somewhat by dragging in a few pragmatic chapters, such as those on "Plant Diseases of International Importance" or "Diseases in Transit and Storage." Nevertheless, I am impressed with the depth of the thinking in the book. I think it is a milestone on the long, long road from the mystic notions of spontaneous generation to a deep understanding of the nature of disease in plants.

JAMES G. HORSFALL
Connecticut Agricultural Experiment Station, New Haven

The Infectious Diseases of Domestic Animals. With special reference to etiology, diagnosis, and biologic therapy. William A. Hagan and Dorsey W. Bruner. Comstock Division, Cornell University Press, Ithaca, N.Y., ed. 3, 1957. xx + 968 pp. Illus. $10.50.

This is primarily a textbook of veterinary microbiology, in which considerable emphasis is placed on infectious diseases. The approach used by the authors has resulted in an outstanding compilation of current knowledge concerning infectious diseases and infectious disease agents, broader in scope than either a text of microbiology or infectious diseases although, of necessity, lacking the detail found in a book of infectious diseases per se. The excellent correlation of the subject matter and the style of writing make this a highly readable text.

As in the previous edition, the book is divided into seven parts which deal, respectively, with the immunological aspect of the host-parasite relationship; chemotherapeutic and antibiotic agents; the pathogenic bacteria; the spirochetes; the bartonella, the rickettsiae, and the pleuropneumonia organisms (these are discussed in part IV, entitled, "Bacterialike Pathogenic Organisms of Uncertain Classification"); the pathogenic fungi; the pathogenic protozoa; and the viruses.

The book has been brought up to date by the incorporation of much recent pertinent work and by the inclusion of several additional tables and illustrations and a greater number of references. The over-all length exceeds that of the previous edition by approximately 50 pages.

In my opinion the book is superior to any other of its kind currently available in the field. Fundamental information is stated clearly, impartial treatment is accorded controversial issues, and balance has been achieved by selective emphasis of the subject matter. Exotic diseases, which are an ever-present threat to the livestock industry of this country, receive considerable attention.

A few minor changes and critical suggestions might be considered for future revisions of the book. Additional pictorial material could have been used to advantage in dealing with the protozoa. A more careful selection of reference material might have contributed to greater completeness in the case of certain diseases discussed (for example, anaplasmosis) and to greater accuracy in certain statements (such as that enzootic abortion of ewes occurs in Australia and New Zealand). Inclusion of the initials of those whose names appear in the reference list would, it is felt, be an improvement.

Omissions are few, although several diseases of considerable importance (such as epididymitis of rams, ovine pneumonia, and virus pneumonia of pigs) are not mentioned. On the other hand, reference to bluetongue as a disease of cattle as well as of sheep is perhaps misleading.

I heartily endorse this book for use in the teaching of veterinary microbiology and infectious diseases and as a ready source of information on essentially all phases of work in the field of infectious disease.

D. G. MCKERCHER
School of Veterinary Medicine, University of California, Davis

Handbuch der Physik. vol. 28, *Spectroscopy II.* S. Flügge, Ed. Springer, Berlin, 1957. vi + 448 pp. Illus. DM. 98.

The first of the five articles contained in this volume deals with microwave spectroscopy (78 pages, in English) and is written by Walter Gordy, one of the leading men in this field. It gives a vivid and clear account of methods, instrumentation, and achievements in this latest branch of spectroscopy, which, despite its youth, has played an important role in atomic, molecular, and solid-state physics and even in astrophysics.

Continuous spectra are treated in the second contribution, by Wolfgang Finkelnburg and Theo Peters. This article (in German) is well organized, covers the field with admirable completeness, and is a reliable source of information.

The third chapter, on crystal spectra, is written (in German) by Eugen Fick and Georg Joos. It excels throughout in clarity and thoroughness, whether it is dealing with the description of phenomena, the presentation of results, or the exposition of theory.

The Zeeman-effect is the subject of the fourth article (written in English). Its author, J. C. Van Den Bosch, is a member of the staff of the famous Zeeman laboratory in Amsterdam. This chapter covers most of the material which is essential for the experimenter. The theoretical discussions are based upon the vector model. The quantum mechanical treatment is found in volume 35 of this encyclopedia. This rather concise article would have gained by the addition of a detailed list of publications relative to the different elements.

The last chapter (in French), on natural optical activity, is by Jean Paul Mathieu. The presence of this chapter in a volume of spectroscopy is rather peculiar but must be justified by interpreting the term *spectroscopy* in a rather broad sense. This article is a thorough, clear, and attractively presented contribution. Historical remarks and general laws, methods of measurements, and optical activity of isotropic and anisotropic media are the main subject-divisions.

Subject indexes in German-English and English-German and a table of contents, in French for the last article, conclude the volume.

K. W. MEISSNER

Purdue University

Synthetic Methods of Organic Chemistry. vol. 10. With reaction titles and cumulative index of vols. 6 to 10; vol. 11. W. Theilheimer, Ed. Karger, Basel, Switzerland; Interscience, New York, 1956, 1957. 746 pp.; 494 pp. $25.25; $20.

In volumes 10 and 11 of this series of annual publications, the editor has continued the important compilation of new synthetic methods and of improved old procedures in the field of organic chemistry.

The tenth volume contains a cumulative alphabetical index for volumes 6 to 10 and, in the body of the text, all reaction titles of these volumes. Most of the entries in the tenth volume deal with publications which appeared in the years 1953–1955. Each abstract enumerates starting materials, products, reaction conditions, and yields. In addition, the original literature and, sometimes, supplementary references are given. This pattern is continued in the eleventh volume, which contains abstracts from papers published between 1954 and 1956. A total of 1679 abstracts are published in these two volumes. They should be of great value to chemists who wish to keep up to date on important developments in synthetic organic chemistry.

HENRY FEUER

Purdue University

The Direction of Research Establishments. Proceedings of a symposium held at the National Physical Laboratory, 26–28 Sept. 1956. National Physical Laboratory. Her Majesty's Stationery Office, London, 1957 (order from British Information Services, 45 Rockefeller Plaza, New York). Four sections. $4.50.

That skillful blend of scientific freedom, wise leadership, and selective allocation of resources which constitutes good research management is a major objective of research directors in industry and government. Many conferences devoted to the problems of research administration have been held in the United States under the sponsorship of various host institutions but without a formal continuing organization. The present book contains the proceedings of the first such conference to be held in Great Britain, one of the series of symposia regularly held by the National Physical Laboratory.

The six sessions included 20 papers by as many authors—14 British, two Canadian, two American, one German, and one Dutch—together with extensive discussion by those in attendance. The first session included papers on the relations between basic and applied research and on the choice and termination of research projects, by J. D. Bernal and Willis Jackson, respectively. The lively discussion ranges from such topics as optimum size of research establishments to the pros and cons of financial awards to individual scientists for particular research successes.

The second session dealt with the problem of creativity, with papers by Morris Stein and D. J. van Lennep. Stein describes a study, carried out by the University of Chicago, of the psychological and sociological factors related to the creativity of American chemists. Creativity, defined as the process resulting in "a novel work that is accepted as tenable or useful or satisfying by a group at some point in time," was determined by the judgment of supervisors, corroborated by that of colleagues and subordinates. Van Lennep studies chemists and physicists from the point of view of applied psychology. In both papers, and in the discussion, creativity seems to be regarded as a quality, probably inherited, which men possess to a greater or lesser degree and which can be brought to its highest expression for a given individual by a suitable environment.

The second session closed with a paper on budgets and administrative controls, by D. R. Willson—a topic which is certainly involved in any consideration of the environment that influences creativity. The author begins by quoting Thomas Jefferson—"The least government is the best government"—an opinion which every research man will heartily endorse. The roles of budgets, project cost accounting, control services, and expenditure controls were debated with as much vigor as in our conferences in the United States.

The third session consisted of four papers on general organization. E. S. Hiscocks describes the growth of scientific research from a craft to a large-scale industry, from the one-man laboratory to team research, and the concomitant necessary changes in organization. He believes, as I do, that "the business of a scientific establishment is to achieve products of scientific thought, and since the spearhead of such an activity lies in the scientists themselves, all other staff are in a sense the tools of the scientists and work to ease their job."

R. Vieweg discusses "Science and the Workshop," coming to the fairly generally accepted conclusion that both a central workshop and small auxiliary shops are required. F. M. Lea and H. A. Snow give advice on the design and provision of buildings in which research is carried out.

The research staff was considered in the fourth session, with five papers: "Selection and Personal Assessment of Staff," by W. S. Bristowe; "Staff Selection and Assessment," by F. T. Rosser; "Superiors and Subordinates in Research," by H. A. Shepard; "Staff Groupings and the Flow of Authority," by C. R. Harington; and "Incentives," by S. Mayne. The first two papers describe the selection and rating procedures in an industrial laboratory (Imperial Chemical Industries) and a governmental laboratory (National Research Council, Canada), respectively. The differences in practice with respect to interviews and weighting of personal factors such as leadership, cooperation and loyalty, power of expression, and personal acceptability are perhaps typical of the two samples rather than representative of characteristic differences between industrial and governmental research laboratories.

Shepard compares the traditional theory of industrial organization with organizational traditions in science and with the new industrial organization theory, which introduces more attention to "human relations." In science, he states, "mutual confidence, rather than authority, is the integrative force in organization," and "the supervisor is the agent for maintaining intragroup and intergroup communication, rather than the agent of higher authority." Much the same views are expressed by C. R. Harington. He says, "authority is the wrong word. . . . It is above all important that the scientific staff should feel that the purpose of the administrative machine is to provide the best conditions for their work and that in no sense is it meant to control their professional activities."

In the final paper of the session on incentives, Mayne stresses the great incentive to scientists of career possibilities and of conditions of work such as freedom in research, professional association and recognition, and similar factors. Pay is important as an incentive but by no means the only factor.

The fifth session dealt with the problems of communicating technical information, both within a research establishment and from the establishment to others. C. G. Williams describes the various techniques and lines of communication in a large research laboratory (Shell Research Ltd.), with stress on the value of personal contacts and the value of colloquia and conferences. L. Moss and L. T. Wilkins describe studies in the use of technical information in the smaller industrial establishments. Their paper is supplemented by a survey of industrial technologists and sources of information in seven European countries. While the studies had not been completed at the time of the symposium, some samples of the results are described.

The remaining three papers of this session treated external communications. A. T. Green and A. E. Dodd chose as their subject, "Knowledge: Passing it On—Getting it Used." In this paper they describe the role of the written word and of exhibition, including newspapers, letters, trade literature, the trade press, research reports, popular research magazines, journals of learned societies, abstracts, memoranda, and textbooks; the appeal to the ear through personal contact, telephone communication, lectures and conferences, and radio; and the appeal to both eye and ear through film, television, and personal instruction and demonstration. Arthur Garratt covers much of the same ground in his paper entitled "Extramural Communications," but is bold enough to assign figures of merit to the various methods, personal contact and the written word being equally effective.

The final paper of this session, by M. W. Thistle, emphasizes some fundamental difficulties encountered in efforts to popularize science—for instance, the barriers of the relation between words and things, of scientific language and sophistication of expression, and of factors of security, of printability, and of receptivity.

One additional formal paper, by A. H. Wilson, on the assessment of the work of an industrial research laboratory, and reports of the chairmen of the several sessions complete the volume. Discussions of the papers, which are rather fully reported, constitute one of the most valuable aspects of the report of this symposium. There were 173 persons in attendance, from 16 different countries, but the publication of this volume makes available the major part of the proceedings to all who are willing to read. I found the report very stimulating and useful, and recommend it to all who are concerned with "the direction of research establishments."

HUGH L. DRYDEN
National Advisory Committee for Aeronautics

Operations Research for Management. vol. II, *Case Histories, Methods, Information Handling.* Joseph F. McCloskey and John M. Coppinger, Eds. Johns Hopkins Press, Baltimore, 1956. xxxiv + 563 pp. $8.

This volume presents a number of papers given before the Johns Hopkins University Informal Seminar on Operations Research during 1953–54 and 1954–55. Many of the papers have been previously published in various journals in the field of operations research.

The first half of the book is devoted to a presentation of case histories which cover such varied areas as "Traffic Delays at Toll Booths" (by Leslie C. Edie), "Revising New York's Subway Fare Structure" (by W. S. Vickrey), "Operational Research in Underground Mining" (by S. L. Cook), and "Bio-Social Research in Operations Research" (by S. W. Davis).

The second section covers discussions of a number of problem-solving procedures which are available. These include an article on experimental design (by W. J. Youden), a good review of the mathematical complexities of the traveling-salesman problem (by M. M. Flood), and an intriguing but all-too-short chapter on operational gaming (by W. E. Cushen).

The final part of the book deals with "Information Handling in Organized Groups." The subjects discussed include the experimental investigation of the efficiency of various communication patterns in small groups. In one section, J. Macy, Jr., discusses communications among human beings in terms of Shannon-Wiener information theory concepts.

This is a book, then, which illustrates the wide range of interests that "operations analysts" are concerned with.

IRVING ROSHWALB
Audits and Surveys Company, Inc., New York

Radioastronomie. Raymond Coutrez. Edition du Patrimoine de l'Observatoire Royal de Belgique, Uccle, 1956. vii + 383 pp. Illus. + plates. F. 250.

It is difficult to write a technical book of any lasting value on a new and rapidly developing subject. Radio astronomy is such a subject. Its techniques are in a state of continual change, and it is too young to have acquired any large body of well-established results. The author of *Radioastronomie,* Raymond Coutrez, points out these difficulties in his foreword and then proceeds to make a valiant effort to overcome them. According to the foreword, the book was written to provide, in the French language, an outline of the present status (through 1955) of the techniques and results of radio astronomy. In this it succeeds quite admirably. The book is, however, very much an outline in that it covers a large number of topics very briefly, without doing full justice to any. This is rather regrettable in some cases, since much of the material is straightforward astronomy, electronics, and physics, which will be familiar to most readers, or readily obtainable, and might well have been omitted in favor of fuller discussion of those techniques peculiar to radio astronomy. The book is definitely not for the layman, since the author presupposes a fair knowledge of physics and electronics on the part of the reader.

The first five chapters deal with the physics of radiation, general properties of antennas, transmission lines, receivers, and special antenna and receiver techniques used in radio astronomy. As a whole, these chapters provide what is probably the best discussion of the techniques of radio astronomy that is presently available in a single compilation. Chapters VI and VIII give a thumbnail sketch of optical astronomy, which, in my opinion, adds nothing to the book. Chapter VII discusses solar radio astronomy, chapter IX covers galactic and extragalactic radio astronomy, and the final chapter is concerned with meteors, the moon, and the planets.

In general, the book is clearly and concisely written. In only a few places—in the section describing the various defi-

nitions of temperature, for example—is the discussion vague or difficult to follow. Original sources of work are systematically quoted throughout the book, with references listed at the end of each chapter. For those who are seriously interested in the subject, *Radioastronomie* should be a useful reference work; for those just entering the field it provides a good survey of techniques, summary of results through 1955, and guide to the literature.

D. S. HEESCHEN
National Radio Astronomy Observatory, Green Bank, West Virginia

Science in Australian Primary Schools. C. D. Hardie, Ed. Melbourne University Press, Carlton, Australia, 1957 (order from Cambridge University Press, New York). 90 pp. $3.75.

Five Australian educators have pooled their resources in the production of this slight volume, which is designed to describe the present status of science in the first six grades in Australia. The book intends to describe present conditions and problems rather than solve them. It appears that the problems in the elementary schools of Australia are in many ways much the same as those in the United States—lack of adequate science background of teachers in the elementary schools, need for a better organized curriculum, and so on. The book will be of some use to curriculum workers, to teachers' college personnel charged with the education of teachers, and to those interested in in-service teacher education. The vast task of educating elementary teachers for their job of effective science instruction appears to be as urgent to our neighbors as it does to us. There is a summary chart showing, in brief outline form, the science curriculum in various sections of Australia at the present time.

GLENN O. BLOUGH
University of Maryland

New Books

In Search of Man. André Missenard. Translated by Lawrence G. Blochman. Hawthorn Books, New York, 1957. 348 pp. $5.95.

An Introduction to Method in Psychology. W. M. O'Neil. Melbourne University Press, Carlton, Victoria, Australia, 1957 (order from Cambridge University Press, New York). 164 pp. $4.50.

Industrial Chemicals. W. L. Faith, Donald B. Keyes, Ronald L. Clark. Wiley, New York; Chapman & Hall, London, ed. 2, 1957. 853 pp. $16.

The Human Sum. C. H. Rolph, Ed. Macmillan, New York, 1957. 238 pp. $3.75.

Exploring the Atmosphere's First Mile. vol. I, *Instrumentation and Data Evaluation*; vol. II, *Site Description and Data Tabulation.* Proceedings of the Great Plains Turbulence Field Program 1 Aug.–8 Sept. 1953, O'Neill, Nebraska. Heinz H. Lettau and Ben Davidson, Eds. Pergamon Press, New York and London, 1957. 592 pp. $20.

Buddhist Himalaya. Travels and studies in quest of the origins and nature of Tibetan religion. D. L. Snellgrove. Philosophical Library, New York, 1957. 336 pp. $10.

Integral Equations. And their applications to certain problems in mechanics, mathematical physics and technology. S. G. Mikhlin. Translated from the Russian by A. H. Armstrong. Pergamon Press, New York and London, 1957. 350 pp. $12.50.

The Exact Sciences in Antiquity. O. Neugebauer. Brown University Press, Providence, R.I., ed. 2, 1957. 256 pp. $6.

Information Systems in Documentation. J. H. Shera, A. Kent, J. W. Perry. Interscience, New York, 1957. 658 pp. $12.

Tracer Applications for the Study of Organic Reactions. John G. Burr, Jr. Interscience, New York, 1957. 301 pp. $7.50.

Araucanian Child Life and Its Cultural Background. Smithsonian Misc. Collections, vol. 133. Sister M. Inez Hilger. Smithsonian Institution, Washington, 1957. 459 pp.

Traité de Chimie Biologique. vol. 1, *Aminoacides, Protéines, Portéases, Nucléines, Porphyrines, Enzymes Respiratoires.* Louis Genevois. Presses Universitaires de France, Paris, 1957. 333 pp. F. 1800.

Applied Hydro- and Aeromechanics. Based on lectures of L. Prandtl. O. G. Tietjens. Translated by J. P. Den Hartog. Dover, New York, 1957. 327 pp. $1.85.

Psychological Development Through the Life Span. Sidney L. Pressey and Raymond G. Kuhlen. Harper, New York, 1957. 680 pp. $6.

Quantitative Plant Ecology. P. Greig-Smith. Academic Press, New York; Butterworths, London, 1957. 208 pp. $6.

Insights into Modern Mathematics. Twenty-third yearbook. National Council of Teachers of Mathematics, Washington, 1957. 448 pp. $5.75.

Scientific American Books. Lives in Science, 274 pp.; *New Chemistry,* 206 pp.; *Plant Life,* 237 pp. By the editors of *Scientific American.* Simon and Schuster, New York, 1957. $1.45 each.

Shock and Circulatory Homeostasis. Transactions of the Fifth Conference, 30 Nov.–2 Dec. 1955, Princeton, N.J. Harold D. Green, Ed. Josiah Macy, Jr. Foundation, New York, 1957. 337 pp. $4.75.

Inorganic Syntheses. Therald Moeller, Ed. McGraw-Hill, New York, 1957. 279 pp. $6.

Economics of Atomic Energy. Mary Goldring. Philosophical Library, New York, 1957. 184 pp. $6.

Atomic Energy in Agriculture. William E. Dick. Philosophical Library, New York, 1957. 160 pp. $6.

Fossil Men. Marcellin Boule and Henri V. Vallois. Translated by Michael Bullock. Dryden Press, New York, 1957. 560 pp. $9.50.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Pest Infestation Research 1956. The report of the Pest Infestation Research Board with the report of the director of pest infestation research. 64 pp. $0.86.

Fuel Research, 1956. Report of the Fuel Research Board with the report of the director of fuel research for 1956. 80 pp. $0.86. Department of Scientific and Industrial Research, London, 1957 (order from British Information Services, 45 Rockefeller Plaza, New York 20).

Preparation of Mutually Consistent Magnetic Charts. Geophysical Research Paper No. 55. ASTIA Document No. AD 117268. P. Fougere and J. McClay. Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Mass., 1957 (order from ASTIA, Document Service Center, Dayton 2, Ohio). 44 pp.

Spherical Waves of Finite Amplitude. WADC Tech. Rept. 57-463. ASTIA Document No. AD 130949. Donald T. Laird, Eugene Ackerman, James B. Randels, Hans L. Oestreicher. 125 pp. *WAF Trainee Body Dimensions: A Correlation Matrix.* WADC Tech. Rept. 57-197. ASTIA Document No. 118161. Edmund Churchill and Katherine Bernhardi. 75 pp. *Estimation of the Mass of Body Segments.* WADC Tech. Rept. 57-260. ASTIA Document No. 118222. James T. Barter. 10 pp. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1957 (order from ASTIA Document Service Center, Knott Building, Dayton 2).

National Research Council of Canada, 1956–57, Fortieth Annual Report. Including the annual report of Canadian Patents and Development Limited. The Council, Ottawa, Canada, 1957. 120 pp.

Economic Geography of Ohio. Bull. 50. Alfred J. Wright. Division of Geological Survey, Columbus, Ohio, ed. 2, 1957. 263 pp.

Some Littoral Barnacles from the Tuamotu, Marshall, and Caroline Islands. Proceedings of the U.S. National Museum, vol. 107. Dora Priaulx Henry. Smithsonian Institution, Washington, 1957. 14 pp.

Vocational Training and Rehabilitation of Exceptional Children. Proceedings of the 1957 spring conference of the Woods Schools, held in Chicago 10–11 May. Woods School, Langhorne, Penn., 1957. 144 pp.

United States Atomic Energy Commission, 1957 Financial Report. U.S. Atomic Energy Commission, Washington, 1957. 39 pp.

Oak Ridge Institute of Nuclear Studies, Eleventh Annual Report. Operating under contract with the U.S. Atomic Energy Commission. The Institute, Oak Ridge, Tenn., 1957. 86 pp.

Helen Hay Whitney Foundation, Third Report. 1 Jan. 1955–30 June 1957. The Foundation, 525 E. 68 Street, New York 21, 1957. 33 pp.

Zinc Oxide Rediscovered. Harvey E. Brown. New Jersey Zinc Co., New York 38, 1957. 99 pp. $3.

Meetings and Societies

Bioclimatology

The International Society of Bioclimatology and Biometeorology (ISBB) held its first scientific congress in Vienna, Austria, 23 to 27 Sept. 1957. The meeting was attended by 137 persons from 33 nations. The objectives of this first congress were (i) to begin to synthesize the established generalizations in bioclimatology, (ii) to outline the major problems requiring investigation, and (iii) to discuss experimental approaches to the solution of those problems. To these ends, the executive board of the society had invited various experts to present papers aimed at implementing these objectives from the point of view of their particular branches of bioclimatology.

Three papers on general bioclimatology were presented: "Concepts and techniques in bioclimatological training of graduate students" (F. Sargent, II); "Beobachtung, Experiment, und Statistik in der Bioklimatologie und Biometeorologie" (H. Berg); and "Die Schwebstoffe in der Luft und ihre Bioklimatische Bedeutung" (H. Nückel).

In the field of phytological bioclimatology there were four papers: "Allgemeine Phytobioklimatologie (Methoden, Probleme, und neue Arbeitsergebnisse)" (R. Knapp); "Thermal and photothermal requirements of pure-line varieties of plants as a biological indicator in ascertaining climatic analogues (homoclimes)" (M. Y. Nuttonson); "Phytoclimatologie et silviculture" (A. de Philippis); and "Les plantes et le climat: quelques aspects particuliers des buts et des méthodes de la bioclimatologie agricole" (H. Geslin).

There were two papers on insect bioclimatology: "Biometeorology and the displacements of airborne insects" (R. C. Rainey), and "Meteorology and population dynamics" (W. G. Wellington).

Two papers represented veterinary bioclimatology: "Bioklimatologische Probleme der Veterinär-Medizin" (R. Koller), and "Physiological effect of climatic stress on the bovine animal" (J. D. Findlay).

In the field of human bioclimatology there were papers on both physiology and pathology: "Influence du climat tropical sur le comportement physiologique de l'homme" (R. Lemaire); "Acclimatization to heat in man and animals" (J. S. Weiner, A. R. Lind, and G. A. Harrison); "Wetterfüligkeit und Klima-Therapie" (W. Amelung).

There was one paper on architectural bioclimatology—"Some aspects of building bioclimatology" (J. K. Page)—and one on cosmic bioclimatology—"Phénomènes cosmiques et bioclimatologie" (G. Piccardi).

Eighty-four brief reports were submitted, dealing with general, phytological, agricultural, zoological, entomological, and human aspects of bioclimatology. Of these, 48 were presented at the congress; the remainder, together with all papers read, will be published in the *International Journal of Bioclimatology and Biometeorology*.

Taken as a whole, these papers depict the scope of bioclimatology, its methods, its concepts, and its problems. Within this science there are areas where the concepts and observations have a solid experimental foundation. On the other hand, there are parts wherein speculation overtaxes the facts and inadequate controls do not justify the conclusions drawn. The severest experimental design is required in all bioclimatological investigation because the order of magnitude of change is frequently small and because multiple variables are involved. Some of the central questions of bioclimatology are within this realm—for example, meteorotropism, weather-sensitivity, and climatotherapy. That they are still far from solution was a major conclusion of the congress.

In order to investigate and review critically the various areas of bioclimatological knowledge, the society has established a number of technical committees. New committees formed at the Vienna congress were the Committee on Tropical Bioclimatology, the Committee on Chemical Tests, the Committee to Coordinate Bioclimatological Activities of ISBB and U.N. Agencies, and the Committee on Solar Radiation. Chairmen of established committees [F. Sargent, II, K. Buettner, D. H. K. Lee, *Science* **124**, 1299 (1956)] gave reports of the work of their groups. For further information about these committees and about the society, address communications to S. W. Tromp, Secretary, Hofbrouckerlaan 54, Oegstgeest (Leiden), Holland.

The real achievement of the congress was the demonstration that, in a multidisciplinary science such as bioclimatology, there was a common ground for discussion which would ultimately make possible an integrative approach to the significant problems of human and animal health and welfare. Not only must bioclimatology deal with the physical environmental factors affecting living organisms but it must also deal with the physiological and pathophysiological mechanisms underlying the responses of the organism. Key problems thus require a cooperative approach involving the meteorologist, biologist, and medical scientist. Evidence that such an approach would be practicable within the framework of future congresses was indicated by the lively discussion promoted by papers touching on such problems and by the decision of the members to devote a large share of future meetings to discussion of some of these matters. The spirit of this first meeting thus demonstrated an underlying desire of the membership to get on with the job of synthesizing bioclimatological knowledge and of tackling those major questions which would yield to a broad, multidisciplinary approach.

FREDERICK SARGENT, II
Department of Physiology, University of Illinois, Urbana

Forthcoming Events

February

6–7. Western Spectroscopy Assoc., 5th annual, Asilomar, Calif. (K. J. Palmer, U.S. Dept. of Agriculture, 800 Buchanan St., Albany 10, Calif.)

8–11. Medical Education and Licensure, 5th annual cong., Chicago, Ill. (Council on Medical Education and Hospitals, American Medical Assoc., 535 N. Dearborn St., Chicago 10.)

10–14. **American Soc. for Testing Materials, St. Louis, Mo. (F. F. Van Atta, ASTM, 1916 Race St., Philadelphia 3, Pa.)**

13–15. **National Soc. of Professional Engineers, spring, East Lansing, Mich. (NSPE, 2029 K St., NW, Washington 6.)**

16–20. **American Inst. of Mining, Metallurgical and Petroleum Engineers, annual, New York. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)**

20–21. **Transistor and Solid State Circuits Conf., Philadelphia, Pa. (J. H. Milligan, Jr., Dept. of Electrical Engr., New York Univ., New York 53.)**

22–25. **American Educational Research Assoc., St. Louis, Mo. (F. W. Hubbard, AERA, 1201 16th St., NW, Washington 6.)**

24–28. **American Soc. of Civil Engineers, Chicago, Ill. (W. W. Wisely, ASCE, 33 W. 39 St., New York 18.)**

March

1. Junior Solar Symposium, Tempe, Ariz. (Association for Applied Solar Energy, 3424 N. Central Ave., Phoenix, Ariz.)

1–3. National Wildlife Federation, St. Louis, Mo. (E. F. Swift, NWF, 232 Carroll St., NW, Washington 12.)

3. Wildlife Soc., annual, St. Louis, Mo. (D. L. Leedy, U.S. Fish and Wildlife Service, Washington 25.)

5–6. Gas Conditioning Conf., 7th annual, Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

6–8. Fundamental Cancer Research, 12th annual, Houston, Tex. (W. K. Sinclair, M. D. Anderson Hospital and Tumor Inst., Univ. of Texas, Houston 25.)

10–13. American Assoc. of Petroleum Geologists, annual, Los Angeles, Calif. (R. H. Dott, AAPG, Box 979, Tulsa 1, Okla.)

10–13. Society of Economic Paleontologists and Mineralogists, annual, Los Angeles, Calif. (R. H. Dott, Box 979, Tulsa, Okla.)

16–21. Nuclear Engineering and Science Cong., Chicago, Ill. (D. I. Cooper, *Nucleonics,* 330 W. 42 St., New York.)

17–21. National Assoc. of Corrosion Engineers, 14th annual, San Francisco, Calif. (NACE, Southern Standard Bldg., Houston 2, Tex.)

18–20. Amino Acids and Peptides, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

20–22. Michigan Acad. of Science, Arts and Letters, annual, Ann Arbor. (R. F. Haugh, Dept. of English, Univ. of Michigan, Ann Arbor.)

20–22. Pulmonary Circulation Conf., Chicago, Ill. (Wright Adams, Chicago Heart Assoc., 69 W. Washington St., Chicago 2.)

20–23. International Assoc. for Dental Research, annual, Detroit, Mich. (D. Y. Burrill, Northwestern Univ. Dental School, 311 E. Chicago Ave., Chicago 11, Ill.)

23–26. American Assoc. of Dental Schools, annual, Detroit, Mich. (M. W. McCrea, 42 S. Greene St., Baltimore 1, Md.)

23–29. American Soc. of Photogrammetry, 24th annual, jointly with American Cong. on Surveying and Mapping, 18th annual, Washington, D.C. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5.)

24–26. Aero Medical Assoc., 29th annual, Washington, D.C. (T. H. Sutherland, Box 26, Marion, Ohio.)

24–27. Institute of Radio Engineers, natl. conv., New York. (G. W. Bailey, IRE, 1 E. 79 St., New York 21.)

26–28. American Power Conf., 20th annual, Chicago, Ill. (Illinois Inst. of Technology, 35 W. 33 St., Chicago 16.)

27–29. Mechanisms of Hypersensitivity, 8th internatl. symp., Detroit, Mich. (W. J Nungester, Dept. of Bacteriology, Univ. of Michigan, Ann Arbor.)

27–29. National Science Teachers Assoc., 6th natl., Denver, Colo. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

27–29. Optical Soc. of America, Washington, D.C. (S. S. Ballard, Scripps Institution of Oceanography, San Diego 52, Calif.)

29. South Carolina Acad. of Science, annual, Charleston. (Miss M. Hess, Dept. of Biology, Winthrop College, Clemson, S.C.)

29–30. American Psychosomatic Soc., 15th annual, Cincinnati, Ohio. (T. Lidz, 551 Madison Ave., New York 22.)

30–3. American College Personnel Assoc., annual, St. Louis, Mo. (L. Riggs, DePauw Univ., Greencastle, Ind.)

April

1–3. Corrosion Control, 5th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

2–4. American Assoc. of Anatomists, annual, Buffalo, N.Y. (L. B. Flexner, Dept. of Anatomy, School of Medicine, Univ. of Pennsylvania, Philadelphia 4.)

2–4. Instruments and Regulators Conf., Newark, Del. (W. E. Vannah, Control Engineering, 330 W. 42 St., New York 36.)

4–5. Southern Soc. for Philosophy and Psychology, annual, Nashville, Tenn. (W. B. Webb, U.S. Naval School of Aviation Medicine, Pensacola, Fla.)

7–11. American Assoc. of Cereal Chemists, annual, Cincinnati, Ohio. (J. W. Pence, Western Utilization Research Laboratories, Albany, Calif.)

8–10. Electronic Waveguides Symp., New York. (J. Fox, Microwave Research Inst., Polytechnic Inst. of Brooklyn, 55 Johnson St., Brooklyn 1, N.Y.)

9–12. National Council of Teachers of Mathematics, Cleveland, Ohio. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

9–14. Applied Psychology, 13th internatl. cong., Rome, Italy. (L. Meschieri, National Inst. of Psychology, Rome.)

10–11. American Inst. of Chemists, annual, Los Angeles, Calif. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

10–12. Biometric Soc., ENAR, Gatlinburg, Tenn. (T. W. Horner, General Mills, Inc., 400 Second Ave. South, Minneapolis 1, Minn.)

10–12. National Speleological Soc., annual, Gatlinburg, Tenn. (G. W. Moore, Geology Dept., Yale Univ., New Haven, Conn.)

10–12. Ohio Acad. of Science, annual, Akron, Ohio. (G. W. Burns, Dept. of Botany, Ohio Wesleyan Univ., Delaware, Ohio.)

11. Vitamin B-12 Symp., New York, N.Y. (Miss J. Watson, 451 Clarkson Ave., Brooklyn 3, N.Y.)

11–12. Eastern Psychological Assoc., annual, Philadelphia, Pa. (G. Lane, Dept. of Psychology, University of Delaware, Newark.)

11–18. Horticultural Cong., 15th internatl., Nice, France. (Secretariat General, 84, rue de Grenelle, Paris 7°, France.)

13–14. American Soc. for Artificial Internal Organs, Philadelphia, Pa. (G. Schreiner, Georgetown Univ. Hospital, Washington 7.)

13–18. American Chemical Soc., 133rd, San Francisco, Calif. (R. M. Warren, ACS, 1155 16 St., NW, Washington 6.)

13–19. Federation of American Societies for Experimental Biology, annual, Philadelphia, Pa. (M. O. Lee, FASEB, 9650 Wisconsin Ave., Bethesda 14, Md.)

14–16. Automatic Techniques Conf. Detroit, Mich. (J. E. Eiselein, RCA, Bldg. 10–7, Camden 2, N.J.)

14–18. American Assoc. of Immunologists, annual, Philadelphia, Pa. (F. S. Cheever, Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

14–18. American Soc. for Experimental Biology, annual, Philadelphia, Pa. (J. F. A. McManus, Univ. of Alabama Medical Center, Birmingham.)

14–18. American Soc. of Biological Chemists, annual, Philadelphia, Pa. (P. Handler, Dept. of Biochemistry, Duke University School of Medicine, Durham, N.C.)

15–17. Gas Measurement, 34th annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

16–25. Instruments, Electronics and Automation Conf., London, England. (Industrial Exhibitions Ltd., 9 Argyll St., London, W.1.)

17–19. Association of Southeastern Biologists, annual, Tallahassee, Fla. (J. C. Dickinson, Jr., Dept. of Biology, Univ. of Florida, Gainesville.

18. Iowa Acad. of Science, annual, Des Moines. (C. H. Lindahl, Dept. of Mathematics, Iowa State College, Ames.)

18–19. Arkansas Acad. of Science, annual, Little Rock. (L. F. Bailey, Botany Dept., Univ. of Arkansas, Fayetteville.)

19–21. American College of Apothecaries, Los Angeles, Calif. (R. E. Abrams, Hamilton Court, 39th and Chestnut St., Philadelphia, Pa.)

20–22. American Assoc. of Colleges of Pharmacy, annual, Los Angeles, Calif. (G. L. Webster, College of Pharmacy, Univ. of Illinois, 808 S. Wood St., Chicago, 12.)

20–23. Chemical Engineering Conf., Canada-United States, Montreal, Quebec, (H. R. L. Streight, DuPont Company of Canada, P.O. Box 660, Montreal.)

21–23. American Oil Chemists' Soc., Memphis, Tenn. (Mrs. L. R. Hawkins, AOCS, 35 E. Wacker Dr., Chicago 1, Ill.)

21–28. American Industrial Hygiene Assoc., annual, Atlantic City, N.J. (G. D. Clayton, George D. Clayton and Associates, 14125 Prevost, Detroit 27, Mich.)

22–24. Electronic Components Symp., Los Angeles, Calif. (E. E. Brewer, Convair, Inc., Pomona, Calif.)

23–26. Internal Medicine, 5th internatl. cong., Philadelphia, Pa. (E. R. Loveland, 4200 Pine St., Philadelphia 4.)

24–25. Eastern States Health Education Conf., New York (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

24–26. West Virginia Acad. of Science, annual, Morgantown. (M. Ward, Glenville State College, Glenville, W. Va.)

25–26. Georgia Acad. of Science, annual, Emory Univ., Emory. (M. T. Clark, Chemistry Dept., Emory Univ., Emory, Ga.)

25–26. Louisiana Acad. of Sciences, annual, Shreveport. (H. B. Boudreaux, Louisiana State Univ., Baton Rouge 3.)

27–1. American Ceramic Soc., 60th annual, Pittsburgh, Pa. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

27–1. Electrochemical Soc., spring, New York. (H. B. Linford, ES, 1860 Broadway, New York 23.)

27–1. Southwestern and Rocky Mountain Div., AAAS, annual, Las Vegas, N.M. (M. G. Anderson, New Mexico A.&M. College, Las Cruces.)

28–29. Automatic Control in the Petroleum and Chemical Industries, 3rd annual conf., Norman, Okla. (M. L. Powers, Extension Div., Univ. of Oklahoma, Norman.)

28–3. Engineering Societies of Western Europe and the United States, conf. (closed), New York. (C. E. Davies, American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18.)

May

1–3. Kansas Acad. of Science, annual, Ottawa. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

1–3. Midwestern Psychological Assoc., Detroit, Mich. (D. W. Fiske, Dept. of Psychology, University of Chicago, Chicago 37).

1–8. American Soc. of Tool Engineers, 26th annual, Philadelphia, Pa. (ASTE, 10700 Puritan, Detroit 38, Mich.)

2. Southern California Acad. of Sciences, annual, Los Angeles. (Miss G. Sibley, Los Angeles County Museum, Exposition Park, Los Angeles 7, Calif.)

2–3. Minnesota Acad. of Science, Bemidji. (M. R. Boudrye, 51 University Ave., St. Paul 3, Minn.)

2–3. North Carolina Academy of Science, annual, Durham. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

2–3. North Dakota Academy of Science, 50th anniversary, Fargo. (B. G. Gustafson, Box 573, University Station, Grand Forks, N.D.)

3–4. Population Assoc. of America, annual, Chicago, Ill. (D. O. Price, Inst. for Research in Social Science, Univ. of North Carolina, Chapel Hill.)

5–7. American Geophysical Union, 39th annual, Washington, D.C. (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5.)

6–9 Western Joint Computer Conf., Los Angeles, Calif. (W. H. Ware, Rand Corp., 1700 Main St., Santa Monica, Calif.)

6–9. International Commission of Optics, colloquium, Brussels, Belgium. (W. D. Wright, Imperial College, South Kensington, London, S.W.7.)

7–9. Acoustical Soc. of America, annual, Washington, D.C. (W. Waterfall, 335 E. 45 St., New York 17.)

7–10. Virginia Academy of Science, annual, Roanoke. (P. M. Patterson, Dept. of Science, Hollins College, Hollins, Va.)

7–11. American Psychoanalytic Assoc., San Francisco, Calif. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

8–9. Colorado-Wyoming Acad. of Science, annual, Denver, Colo. (R. G. Beidleman, Zoology Dept., Colorado College, Colorado Springs.)

8–10. Illinois State Academy of Science, 51st annual, Urbana. (R. A. Evers, Illinois Natural History Survey, Urbana.)

12–14. High Polymer Forum, 8th Canadian, Ste. Anne de Bellevue, Quebec. (M. H. Jones, Dept. of Chemistry, Ontario Research Foundation, 43 Queens Park, Toronto 5, Ont.)

12–14. Instrumental Methods of Analysis, internatl. Symp., Houston, Tex. (H. S. Kindler, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh, Pa.)

12–16. American Psychiatric Assoc., annual, San Francisco, Calif. (D. Blain, APA, 1785 Massachusetts Ave., NW, Washington 6.)

14. American Acad. of Arts and Sciences, Brookline, Mass. (R. W. Burhoe, 280 Newton St., Brookline 46.)

14–16. Society for Experimental Stress Analysis, Cleveland, Ohio. (W. M. Murray, P.O. Box 168, Cambridge 39, Mass.)

15–16. Operations Research Soc. of America, Boston, Mass. (M. L. Ernst, Box 2176, Potomac Station, Alexandria, Va.)

18–24. Sanitary Engineering, 6th Inter-American Cong., San Juan, Puerto Rico. (E. Ortega, Box 218, San Juan.)

19–21. American Trudeau Soc., 53rd annual, Philadelphia, Pa. (K. R. Boucot, Woman's Medical College, Philadelphia.)

20–22. Biosynthesis of Terpenes and Sterols, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

25–29. Institute of Food Technologists, annual, Chicago, Ill. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3.)

25–31. International Soc. of Gastroenterology, 3rd world cong., Washington, D.C. (H. M. Pollard, University Hospital, Ann Arbor, Mich.)

26–28. American Soc. for Quality Control, annual, Boston, Mass. (W. P. Youngclaus, Jr., ASQC, 161 W. Wisconsin Ave., Milwaukee 3, Wis.)

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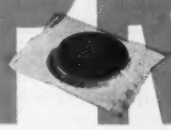

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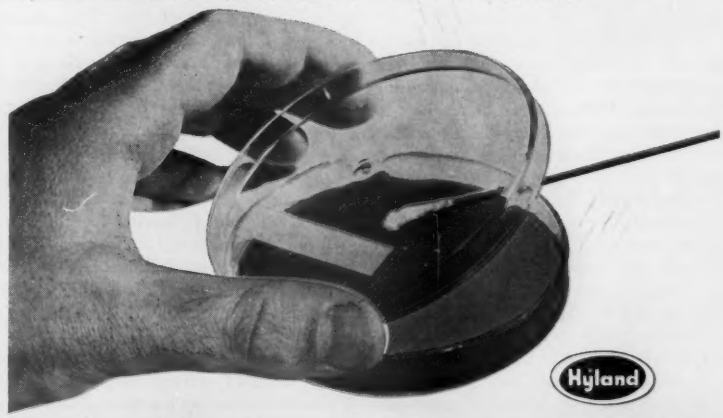

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LETTERS

The editors take no responsibility for the content of the letters published in this section. Anonymous letters will not be considered. Letters intended for publication should be typewritten double-spaced and submitted in duplicate. A letter writer should indicate clearly whether or not his letter is submitted for publication. For additional information, see Science **124**, *249 (1956) and* **125**, *16 (4 Jan. 1957).*

Clock Paradox of Relativity

Edwin M. McMillan attempts "to restate the situation" regarding the clock paradox of relativity, "in new words and all in one place" [*Science* **126**, 381 (30 Aug. 1957)]. Since the controversy on this matter is so widespread and confused, this is indeed a worthy object, but, as he admits that he has "not read widely in the literature of this subject," it is not surprising that he has not succeeded in achieving his objective. His arguments, as he conjectures, have all been given before, and, on the other hand, he appears to have missed the answers to them. I, on the contrary, have been forced to read widely in the literature of the subject and realize, even more than he can do, how necessary it is to bring it to some sort of focus. I therefore willingly take this opportunity of summing up the situation as well as I can, with the double object of showing clearly how the problem now stands and of preventing, as far as possible, further repetition and confusion.

The first thing that calls for elucidation is the meaning of the word *paradox*. In this problem McCrea (*1*) says there is "no paradox," while Crawford (*2*) claims to give a "verification" of it; on examination it transpires that they mean exactly the same thing. Let me at least say what I mean by the word.

A paradox is an apparent contradiction. It arises when two arguments, each apparently sound, lead to incompatible conclusions. Clearly it can be resolved in only one way—namely, by showing that one of the arguments, though apparently sound, is in fact unsound. It cannot be resolved merely by producing additional arguments for one view and leaving the other untouched. To do that is to gild refined gold, which Shakespeare tells us is "wasteful and ridiculous excess"; let me not gild his description.

In this clock paradox the situation, expressed summarily, is this. Einstein (*3*) in 1905 proposed two postulates—the "postulate of relativity" and the "postulate of constant light velocity"—both of which have received abundant confirmation. According to the first, in any case of uniform relative motion (the restriction to uniformity of motion was removed later) there is no phenomenon which will enable one to decide which of the bodies is the absolutely moving one. According to the second postulate (summed up in the Lorentz transformation equations), if you suppose for convenience that one of the bodies is at rest, you must suppose that the other ages less rapidly. These led to contradictory conclusions in the case of two twins, one of whom moves out at a high velocity and returns. The postulate of relativity requires that, since either of them can be the moving one, their ages cannot differ on reunion or there would be a distinguishing phenomenon which would determine which had moved. The other postulate says that since, if we suppose the earthbound twin to be at rest, the other must be supposed to age less rapidly, he will appear younger than his brother when he returns.

My resolution of the paradox is this. I accept the former argument, which seems to me unanswerable. The conclusion drawn from the second postulate is false because the "less rapid aging" is a metaphorical expression. If a clock, B', say, leaves another, B, with which it agrees, and arrives at a distant point P, stationary with respect to B, we cannot tell whether it has kept time or not relatively to B unless there is a clock at P which is synchronized with B, and nature provides no unique means of synchronizing clocks at different places. Einstein's second postulate defines a way of doing this, which is determined by the requirement that the consequences of adopting it must not violate the postulate of relativity; and if this definition be accepted, then B' will be found to be behind a clock at P which is so synchronized with B, on the assumption that B and P are at rest. We rather misleadingly express this by saying that B' has "run slow" during the journey; it would be better to say that the clock at P has been set fast. The essential point, however, is that the equality of times of events at B and at P depends on a process of synchronization which is established by definition, *and which gives different results according to the common motion which we can arbitrarily assign to* B *and* P. Accordingly, if we take B''s point of view for instance, we see B and P moving together, first in one direction until P arrives at B' and then reversing until B again reaches B'. When P arrives at B' it is ahead of B', but B' says that that is because it was wrongly synchronized with B; B synchronized the clocks on the assumption that he and P were at rest, whereas they were both moving together; B has therefore set P too fast. As soon as B and P reverse their motion, however, the synchronization changes. Those same settings are now such that P is too slow (that is, B is too fast) by the same amount. Accordingly, what B' calls the return journey of B exactly compensates for the discrepancy found on the outward journey, and B and B' agree on reunion (*4*).

Now, clearly, if this is right it is a resolution of the paradox; it shows the error in the false argument. So far, no one has found a flaw in this reasoning. Those who hold that asymmetrical aging will occur, however, have *not* offered a resolution of the paradox. To do that they must show that the argument from the postulate of relativity is fallacious, and they have not done so, or even attempted to do so. To simplify refutation I have given the argument from the first postulate in the simplest and most precise form, in a single syllogism (*5*). Let me repeat it here:

1) According to the postulate of relativity, if two bodies (for example, two identical clocks) separate and reunite, there is no observable phenomenon that will show in an absolute sense that one rather than the other has moved.

2) If, on reunion, one clock were retarded by a quantity depending on their relative motion and the other were not, that phenomenon would show that the first had moved and the second had not.

3) Hence, if the postulate of relativity is true, the clocks must be retarded equally or not at all; in either case, their readings will agree on reunion if they agreed at separation.

I have appealed repeatedly for enlightenment as to the flaw in this argument, but without result; I have not even drawn a single comment on it, let alone an answer. I again appeal to those who hold it to be fallacious to tell me where the fallacy lies.

The numerous arguments for asymmetry, on the other hand, show a pitiable state of affairs. Whatever the truth of the matter, they show beyond question that there is a profound and widespread lack of understanding of what relativity means. They fall into the following three broad classes, in each of which there are minor variations: (i) arguments that the asymmetry follows from the Lorentz equations alone, quite independently of the accelerations which occur at starting, reversal, and stopping [Builder (*6*), Fremlin (*7*), Cochran (*8*), and so on]; (ii) arguments that the asymmetry in the problem arises from the fact that one of the bodies, but not the other, must inevitably be accelerated by some mechanical device, but that the nature of this device and the kind of acceleration it produces are immaterial [McCrea (*1*), Crawford (*9*), McMillan (*10*), and so on]; (iii) arguments that the paradox cannot be resolved within the field of special relativity but requires a precise evaluation of the effect of the reversal of motion in terms of Einstein's theory of gravitation [Einstein (*11*), Born (*12*),

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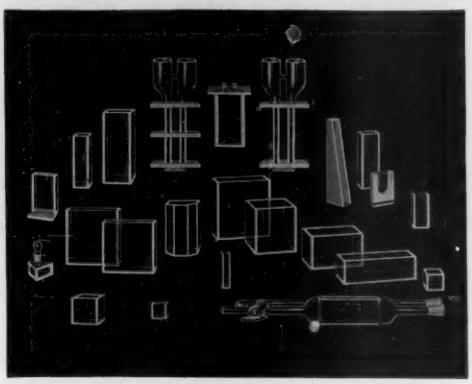

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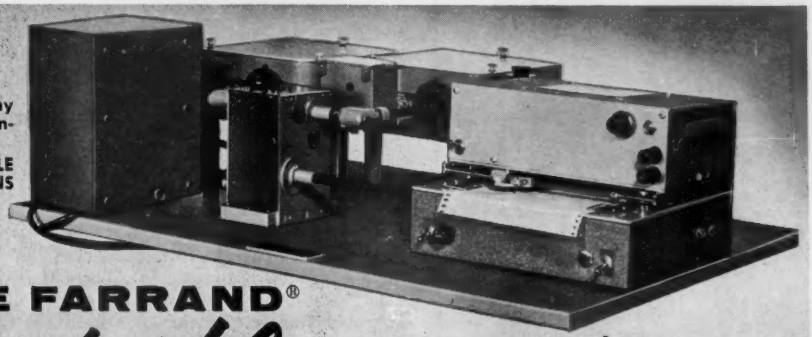

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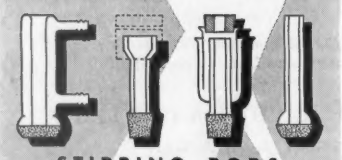

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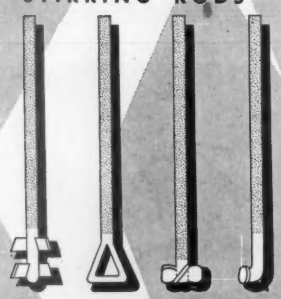

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Tolman (*13*), Møller (*14*), and so on].

It is obvious that if any one of these groups of arguments is sound, the others must be wrong. McMillan, for instance, is definitely at variance with Einstein on this point. As I shall show, Einstein's writings are evidently among the literature which he has not read.

I have attempted to clear up a part of the discrepancy, at least, by analyzing a problem in which there are no accelerations (*4*). B' passes B, moving at uniform relative velocity V, and they observe that their clocks agree at the moment of passing. Some time later, B' meets C coming from the opposite direction (that is, towards B) at velocity V with respect to B, and B' and C note that their clocks agree when they pass. How will C's clock compare with B's when they meet? This is identical with the ordinary clock problem except that there are no accelerations of any kind in it. Those who, like Crawford for instance, accept argument ii or iii should maintain that B's and C's clocks will agree, since they hold the accelerations to be the cause of the asymmetry. Crawford (*9*), however, holds that the same asymmetrical aging should occur here also. I have asked him what causes it in the absence of the accelerations (*5*) but have received no reply.

It remains for me to consider McMillan's arguments very briefly. He has simply evaded the problem. He says: "The usual next step is to have one of the observers reverse his motion, so that ages can be compared directly when the two come together again. However, the argument is just as cogent if we have them come to a state of relative rest, where age comparisons are meaningful even at a distance, and this approach is used because of its simplicity." He then shows that, to use the former notation, B' differs from the clock at P when it meets that clock. But that has never been in dispute. I have had to correct this mistake more than once, in correspondence which he himself has cited (*15*). There is no "state of relative rest, where age comparisons are meaningful even at a distance." The event in California which is simultaneous with an event this moment in London depends, for instance, on whether we regard the earth or the sun as being at rest, notwithstanding the fact that London and California are at relative rest in both cases. I have already reminded Crawford of this fact, without response.

McMillan finds an asymmetry in terms of "inertial systems," as though these were facts of nature instead of arbitrary frames of our own choosing. This error also I have pointed out before (*16*). How remote McMillan is from understanding the matter is shown by his remark that his demonstration "does not involve any arguments from general relativity (except insofar as it may give meaning to the concept of an inertial system)." What general relativity did was, in fact, to *take away* meaning from the concept of an inertial system. It will be sufficient to quote one sentence from Einstein and Infeld's book, *The Evolution of Physics*, occurring in the section on general relativity: "The ghosts of absolute motion and inertial coordinate systems can be expelled from physics and a new relativistic physics built" (page 235).

Finally, I would like to remark that if Crawford would reply to the questions I put to him in my letter in *Nature* of 15 June 1957 (*5*), we might make some advance. There is nothing to be gained by successive writers repeating the old statements and ignoring the answers to them.

HERBERT DINGLE
University of London

References and Notes

1. W. H. McCrea, *Nature* 167, 680 (1951); 177, 784 (1956).
2. F. S. Crawford, Jr., *ibid.* 179, 35 (1957).
3. A. Einstein, *Ann. Phys.* 17, 891 (1905).
4. H. Dingle, *Proc. Phys. Soc.* (*London*) A69, 925 (1956). In this paper the statements made in the text are proved. An alternative and more general proof of the theorem concerning the change of coordinate times on reversal is given in *5*.
5. ———, *Nature* 179, 1242 (1957).
6. G. Builder, *Bull. Inst. Phys.* 8, 210 (1957); *Australian J. Phys.* 10, 246 (1957).
7. J. H. Fremlin, *Nature* 180, 499 (1957).
8. W. Cochran, *ibid.* 179, 977 (1957).
9. F. S. Crawford, Jr., *ibid.* 179, 1071 (1957).
10. E. M. McMillan, *Science* 126, 381 (1957).
11. A. Einstein, *Naturwissenschaften* 6, 697 (1918). Einstein merely outlined the argument but made no calculations; had he done so, I have no doubt that he would have seen that the suggestion would not work. It must be remembered, however, that at that time the problem was a mere curiosity, not worth serious attention, and it was sufficient for his purpose to show that the general theory, which he had recently completed, provided an escape from the contradiction which he agreed the special theory alone could not avoid. Einstein's idea has since been worked out algebraically by the other authors mentioned, but only for small velocities; I have shown that even in these cases it does not remove the contradiction.
12. M. Born, *Einstein's Theory of Relativity* (London, 1924), pp. 216, 282.
13. R. C. Tolman, *Relativity, Thermodynamics and Cosmology* (Oxford, 1934), p. 194.
14. C. Møller, *The Theory of Relativity* (Oxford, 1952), pp. 48, 258.
15. H. Dingle, *Nature* 178, 680 (1956); 179, 865 (1957).
16. ———, *ibid.* 180, 500 (1957).

The editor of *Science* has kindly given me the opportunity to reply to the foregoing letter by Professor Dingle. The next three paragraphs are in the nature of explanations of intent and terminology; following these I shall discuss the more important question: Who is out of step in this parade?

My statement that I had not read widely in the literature of the subject was not meant as an "admission" (presumably of ignorance), as interpreted by Dingle; it was put in to forestall any implication of plagiarism in connection with the material given in the second and third sections of my article. I suspected (correctly) that computations similar to those presented in the third

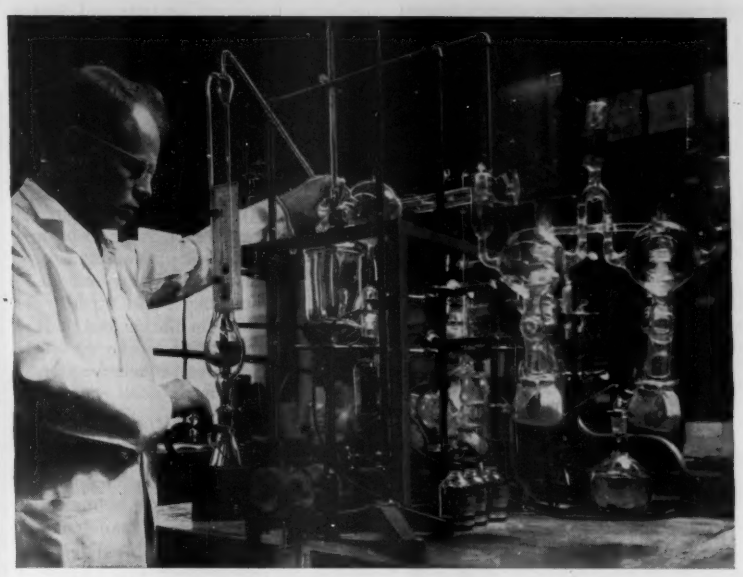
section, on the implications for space travel, had been published elsewhere, while I supposed that my treatment of accelerated coordinate systems in the second section was probably new, and have so far heard nothing to the contrary. The arguments in the first section, on the "paradox" itself, largely follow familiar lines, and I claimed no more than a "restatement" of the situation.

In Dingle's classification of the arguments for asymmetry, mine is placed in the second category, depending on the accelerations, rather than in the first, depending on the Lorentz transformation. In actual fact, all the authors quoted under both of these categories seem to me to understand the problem in the same way, differing only in their presentations. All, in effect, use the Lorentz transformation to compute the time intervals; the acceleration is used only as a kind of "key" to identify changes of coordinate systems, no specific effect of accelerations on clock readings being assumed. In my previous article [*Science* **126**, 381 (1957)], I gave a simple mathematical transformation by which the interpretation of this "key" in terms of time differences can be obtained directly (last equation in the first section).

The phrase "clock paradox" is sometimes used loosely, and in my opinion incorrectly, in referring to the asymmetrical aging itself. Crawford preferred to use it in that sense, although I argued with him at the time that it was an illogical usage. Although we disagreed in a matter of wording, Crawford and I are in complete agreement in matters of principle.

The disagreement between Dingle and the other parties to this controversy is fundamental; someone must be wrong, and the controversy can continue indefinitely unless the error is recognized. In his letter, Dingle uses two independent types of argument, each containing an error which I shall now point out.

One argument is given in the form of a syllogism, whose major premise is: "If two bodies separate and reunite, there is no observable phenomenon that will show in an absolute sense that one rather than the other has moved." This is clearly false. Each body can carry an inertial navigation device in a sealed box (and therefore making only absolute observations); after the completion of the journey, the boxes can be opened, and the recordings made by the devices will contain sufficient information for the construction of complete maps, including velocities, of the motions of the bodies. If one body remains at rest while the other makes a round trip, the two recordings will obviously not be the same. The recordings will not indicate any superimposed uniform motions, but this circumstance is not important; the bodies cannot "separate and reunite"



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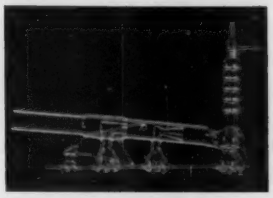

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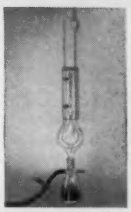

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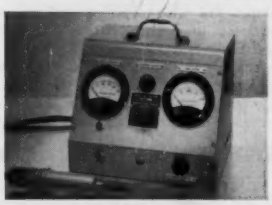

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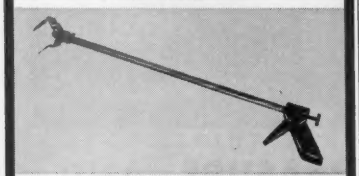

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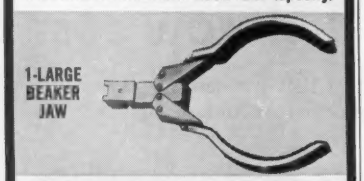

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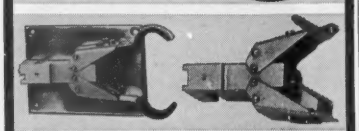

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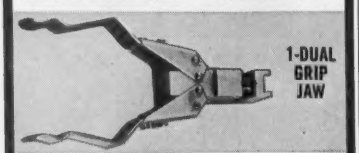

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(or, in my treatment, separate and then come to relative rest) if their *only* motions are uniform. Dingle's example of the three uniformly moving clocks B, B', and C is not a correct parallel to the journey of the twins; to be correct, one twin would have to transfer from B' to C in passing, and his motion would then not be uniform.

Dingle's other argument, used three times in the above letter, is based on a misuse of the concept of simultaneity. He says: "Nature provides no unique means of synchronizing clocks at different places," and from the context it is clear that he means this to apply to cases in which the clocks are at relative rest. Now there is a perfectly good way (in fact, there are many ways) to synchronize distant clocks fixed in the same inertial system. This fact is, as far as I know, recognized in all the standard works on the subject. Dingle, while refusing to accept a criterion of simultaneity in the only case where it is valid, has used it in the case of clocks with relative motion, where it is not valid, in an earlier paper [*Nature* **179**, 1242 (1957)].

In closing, I would like to say that both Crawford and I feel that we have said all that we usefully can on this subject; if further rejoinders should be made, we would be inclined to leave the privilege of replying to others.

EDWIN M. MCMILLAN
University of California, Berkeley

Transport of Molecules into Cells against a Concentration Gradient

In an excellent review of endocrine control of amino acid transfer, Noall, Riggs, Walker, and Christensen [*Science* **126**, 1002 (1957)] assume an enzymatic process in concentrative transfer across cell barriers, or of transport of molecules into cells against concentration gradients. Is it not pertinent here to suggest the possibility that the process may be pinocytosis, the remarkable phenomenon of "cell drinking" which was first described by Warren Lewis [*Bull. Johns Hopkins Hosp.* **49**, 17 (1931)]? This may be beautifully demonstrated in phase-contrast time-lapse movies, as has been done for so many tissues by many competent cytologists.

The free edges of cells in tissue culture, as recorded by phase-contrast time-lapse movies, are in continual wavelike movement, laving the medium around the cells and often sweeping over and engulfing a portion of the surrounding fluid, forming what is usually called a "vacuole," but which contains the various molecules that may be in the surrounding liquid. This "vacuole" may be seen to move toward the center of the cell, into which it has been swept by the curling edges, and, as it moves, the phase boundary between it and the cyto-

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plasm of the cell becomes less and less distinct, until presently there is no "vacuole." Its contents then have been incorporated into the cytoplasm.

Under this interpretation, the action of the hormones cited by Noall and his associates may consist in speeding up the process of pinocytosis, so that the amino acid concentration in cells increases while that of the extracellular fluid decreases. Pinocytosis is applicable of course to many other situations involving "transport against concentration gradients" in regard to cells, or indeed to the entrance of large molecules of any sort into the cytoplasm of cells.

Let us not be misled by the dead appearance of cell boundaries in stained and fixed preparations into thinking *only* and exclusively in terms of a semipermeable membrane and its behavior. In living mammalian cells there is a phase boundary separating the cells from the extracellular fluid around them, and this phase boundary is in continual activity, exhibiting continual pinocytosis. This does not preclude ion passage across the phase boundary, but in the living cell it does suggest the possibility of another mechanism which may be significant when large molecular particles are involved.

CHAUNCEY D. LEAKE
Ohio State University, Columbus
C. M. POMERAT
Medical Branch,
University of Texas, Galveston

The interest of Leake and Pomerat in the paper of Noall *et al.* is greatly appreciated, as is the opportunity of commenting on their suggestion.

Although "cell-drinking" obviously concentrates no extracellular solutes, conceivably active transport is directed toward the contents of a vacuole rather than toward the whole outside environment. Such a narrowing of transport activity to the interior of the cell seems to us to place a *lower* estimate on the potentialities of the cell boundary. In any event the entire process of *active* transport is still left for explanation; in fact, the difficulties in explaining the rate, specificity, and efficiency of the process appear to be more severe.

If it is by pinocytosis that amino acids are transferred into cells, then the engulfing and dissipation of "vacuoles" must be fast enough to account for the rate of entrance of the amino acids. Our colleague Erich Heinz finds that half the glycine of ascites tumor cells is exchanged with labeled glycine from outside in about 2 minutes [*J. Biol. Chem.* **211**, 781 (1954)]. For this to occur by pinocytosis demands that in this brief interval the cell must engulf a quantity of suspending fluid several times its own volume, since the cellular glycine level is many times the extracellular. In addition, an equivalent amount of solvent molecules must be expelled. Our impression is that a substantial part of the cell glycine may be exchanged while a pinocytotic vacuole hesitates at the cell periphery.

A better assessment of the part played by pinocytosis in amino acid uptake comes from the relationship between glycine *influx* and the external glycine *level*, shown in the same investigation. As the glycine level is raised, the engulfed vacuoles will be correspondingly richer in glycine and the initial rate of entrance should rise. In actual fact, as the glycine level was raised the influx soon reached a maximum rate, which then remained constant over a considerable range of glycine levels. It is hard to see how the amount of glycine engulfed pinocytotically could be independent of the external glycine level.

At least in the case of the Ehrlich cells, such results do not appear compatible with a large participation by pinocytosis.

HALVOR N. CHRISTENSEN
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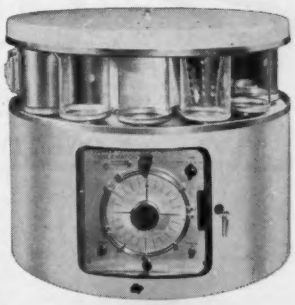

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8-88

EQUIPMENT NEWS

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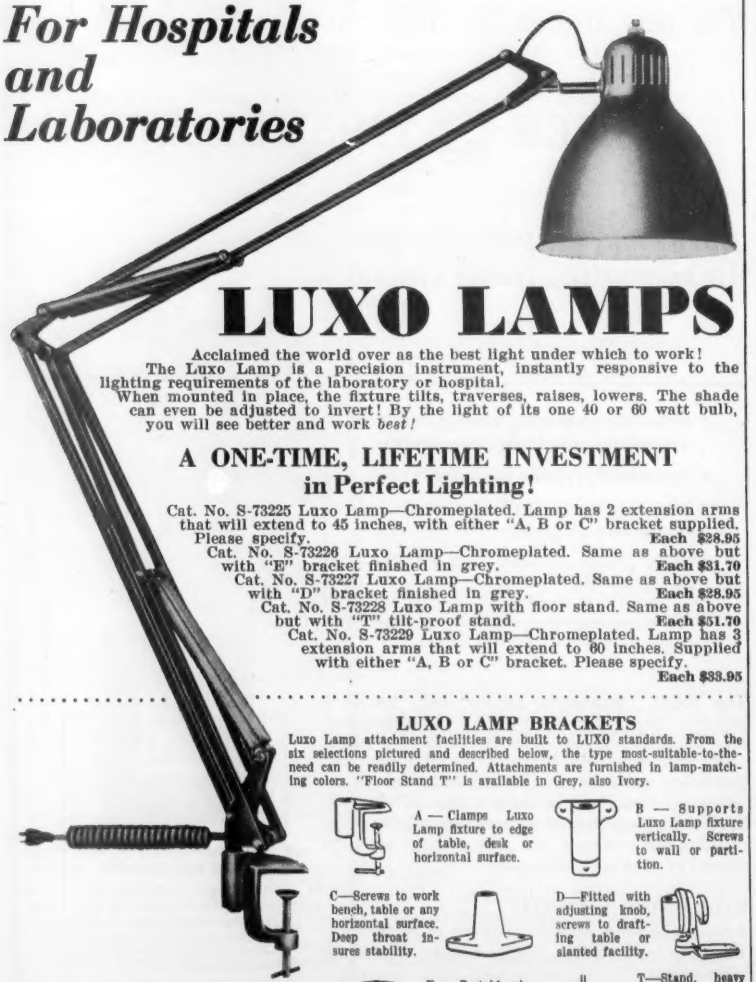

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Acclaimed the world over as the best light under which to work! The Luxo Lamp is a precision instrument, instantly responsive to the lighting requirements of the laboratory or hospital. When mounted in place, the fixture tilts, traverses, raises, lowers. The shade can even be adjusted to invert! By the light of its one 40 or 60 watt bulb, you will see better and work *best!*

A ONE-TIME, LIFETIME INVESTMENT in Perfect Lighting!

Cat. No. S-73225 Luxo Lamp—Chromeplated. Lamp has 2 extension arms that will extend to 45 inches, with either "A, B or C" bracket supplied. Please specify. Each $28.95
Cat. No. S-73226 Luxo Lamp—Chromeplated. Same as above but with "E" bracket finished in grey. Each $31.70
Cat. No. S-73227 Luxo Lamp—Chromeplated. Same as above but with "D" bracket finished in grey. Each $28.95
Cat. No. S-73228 Luxo Lamp with floor stand. Same as above but with "T" tilt-proof stand. Each $51.70
Cat. No. S-73229 Luxo Lamp—Chromeplated. Lamp has 3 extension arms that will extend to 60 inches. Supplied with either "A, B or C" bracket. Please specify. Each $33.95

LUXO LAMP BRACKETS

Luxo Lamp attachment facilities are built to LUXO standards. From the six selections pictured and described below, the type most-suitable-to-the-need can be readily determined. Attachments are furnished in lamp-matching colors. "Floor Stand T" is available in Grey, also Ivory.

A — Clamps Luxo Lamp fixture to edge of table, desk or horizontal surface.

B — Supports Luxo Lamp fixture vertically. Screws to wall or partition.

C—Screws to work bench, table or any horizontal surface. Deep throat insures stability.

D—Fitted with adjusting knob, screws to drafting table or slanted facility.

E — Portable circular base for desk service or for use on any horizontal elevated surface.

T—Stand, heavy base sets on ball-bearing casters. Center shaft is height adjustable, moves easily.

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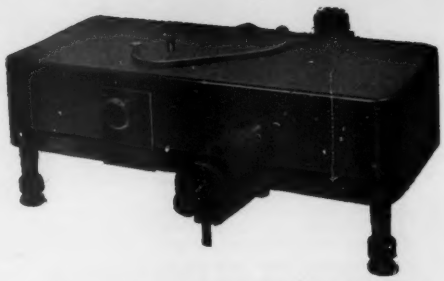

with exchangeable prisms for the visible, ultraviolet, infrared from 200 millimicrons to 20 microns

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95 Madison Ave. New York 16, N.Y.

PERSONNEL PLACEMENT

CLASSIFIED: 25¢ per word, minimum charge $4.25. Use of Box Number counts as 10 additional words. Payment in advance is required.

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Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS OPEN

(a) Bacteriologist; Ph.D. preferred, to head laboratory, 375-bed general hospital unit, university medical school; Southeast. **(b) Biochemist,** M.S. responsible directly to pathologist; approved general hospital 300 beds; to $6500; midwestern college city. **(c) Chief Biochemist;** Ph.D. capable initiating, coordinating clinical, basic research programs; very large, university affiliated hospital; to $8600; Southeast central. **(d) Bacteriologist;** M.S. for clinical, some teaching duties; 300-bed general hospital; to $6000; Mideast. **(e) Pharmacologist;** Ph.D., to direct department of 25, reporting to research director, important eastern company; to $15,000. Woodward Medical Bureau, Ann Woodward, Director, 185 N. Wabash Avenue, Chicago. X

POSITIONS OPEN

Botanist, male, Ph.D. Board training with competence in taxonomy and morphology. Field of research unrestricted.
Geneticist, male, Ph.D. Plant, animal, or microbial. Permanent university positions with graduate and undergraduate teaching and research. Box 8, SCIENCE. 1/17, 24, 31

CHEMISTS AND MATHEMATICIANS; Ph.D. preferred; teaching and research in expanding departments; salary dependent on experience and other qualifications. Inquiries should be addressed to Chairman, Division of the Natural Sciences, Dillard University, New Orleans 22, Louisiana. 12/20, 27; 1/3, 10, 17

GRADUATE ASSISTANTSHIPS IN TEACHING AND RESEARCH available for September 1958. Load from 6 to 20 hours per week. Remainder of time available for graduate work leading to master's degree. Stipends from $550 to $2150.

TEACHING FELLOWSHIPS FOR ADVANCED GRADUATE STUDENTS. Load 12 hours. Stipend, $1800.

Chemistry Department, Howard University, Washington 1, D.C. 2/21

Microbiologist. M.S. or equivalent in microbiology to participate in the analysis of scientific data in connection with research and development activities of large eastern pharmaceutical manufacturer. Liberal benefit program. Send complete personal data. Box 5, SCIENCE. 1/17

Teaching and Research Assistantships available provide partial or complete support during graduate program. Gross anatomy course to be offered this summer is open to graduate students and undergraduate students past junior year, and will provide basic training for teaching to those otherwise unprepared. Inquire Howard A. Matzke, Acting Chairman, Department of Anatomy, University of Kansas, Lawrence, Kansas. 1/10, 17

POSITIONS OPEN

(a) Medical Director; duties: professional correspondence, lecturing, technical consultation, supervising clinical studies; pharmaceutical company; university city, West. **(b) Microbiologist** qualified to assume responsibilities; municipal teaching hospital, 600 beds; extensive educational program; Midwest. **(c) Psychologist** to head department, newly created position; 700-bed general hospital affiliated university medical school; some teaching in future; $7000–$8000; Midwest. **(d) Virologist,** preferably Ph.D.; master's considered; duties consist of conducting survey of research organization; East; junior man, $8000; senior, $12,000–$17,000. **(e) Associate Director of Research in Charge of Pharmaceutical and Organic Research;** key position, one of major pharmaceutical companies; attractive contract; medical school city, Midwest. **(f) Biochemist,** B.S. degree, with training or experience in protein and enzymes; duties consist of supervising biochemical manufacturing and research; East; $8000. **(g) Copywriter;** science degree with experience in pharmaceutical copywriting; well-known manufacturer of pharmaceuticals and biologicals; East. **(h) Psychologist,** Ph.D.; public health department; outside United States; $7000–$8000. **(i) Pharmacologist** with extensive small animal experience to head animal laboratories; organization serving as consultants to food and pharmaceutical industries; well-equipped animal laboratory; medical school city; South. **(j) Biochemist** to head department, 500-bed general hospital; East; $12,000. S1-3 Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

Ph.D. with training in bacteriology and virology to join team in research development of vaccines and their diagnostic methodologies. Salary open. Midwest. Box 14, SCIENCE. 1/24

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

POSITIONS OPEN

Physiologists, Ph.D. Preferably with experience in aviation medicine to work as a team member in aviation research for human factors section. Understanding of statistical methods essential. Contact Mr. H. A. Bodley, Engineering Personnel, CONVAIR, Fort Worth, Texas, for application form. 1/17

POSITIONS WANTED

Biochemist, Scandinavian, age 30, wants employment; 3 years of teaching and research experience in biological kinetics at European university. Apply Box 12, SCIENCE. X

Ecologist, general and physiological; vertebrate zoology. Ph.D.; age 47; professor of zoology. Publications. Desires change in academic position, teaching, and research. Box 325, SCIENCE. 1/10

Pharmaceutical Chemistry–Academic Position, Ph.D., organic-biochemistry, 1948. Teaching experience—pharmaceutical chemistry, biochemistry. Research—antimalarials, carcinolytics, carbohydrate derivatives, development propietaries. Publications, societies. Desires position in pharmaceutical chemistry with opportunity for research. Box 9, SCIENCE. X

Ph.D., Physical Chemistry, June 1954. Experience in protein chemistry, radio chemical techniques, and instrumentation. Academic or industrial research desired. Box 13, SCIENCE. X

The Market Place

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SWISS MICE
TACONIC FARMS
GERMANTOWN, NEW YORK — Phone 3535

POSITIONS WANTED

(a) **Physician;** 6 years' experience in research (nutrition and biochemistry); 7 years, director research, pharmaceutical company. (b) **Bacteriologist;** M.S.; past 3 years, supervisor, bacteriology and clinical laboratory, 300-bed hospital. (c) **Ph.D.** (major, plant pathology; minors, botany, chemistry); 5 years, full-time teaching, medical school; 9 years, director, bacteriology department, major chemical company. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

RESEARCH SCIENTIST, Ph.D. **Physiologist.** Excellent and unusual pre- and postdoctoral hybrid education and training. World-wide academic and professional experience in life sciences (including especially, endocrinology, nutrition, metabolism) as researcher, teacher, administrator; in animal and human experimentation. Young, adept, versatile, energetic, creative, efficient. Desires immediate, challenging foreign or domestic appointment. Send complete details to 3034 Cazador St., Los Angeles 65, Calif. 1/10, 17

Technician (microbiology, chemistry, foods); trying to place in United States extremely able Swiss, 33, planning to emigrate here. Experience: steel analysis, antibiotic pilot plant, food analysis. Write D. M. Reynolds, Associate Professor of Bacteriology, University of California, Davis, Calif. X

Veterinary Research or Teaching, especially qualified in parasitology or avian pathology. Box 10, SCIENCE. X

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

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The exceptional docility of our rats is evidenced first in the ease in which they can be handled. Most important though is the group uniformity of this characteristic. Thus, because of their docility, our rats can often be used to better advantage in research in which growth or internal organic changes are factors under observation.

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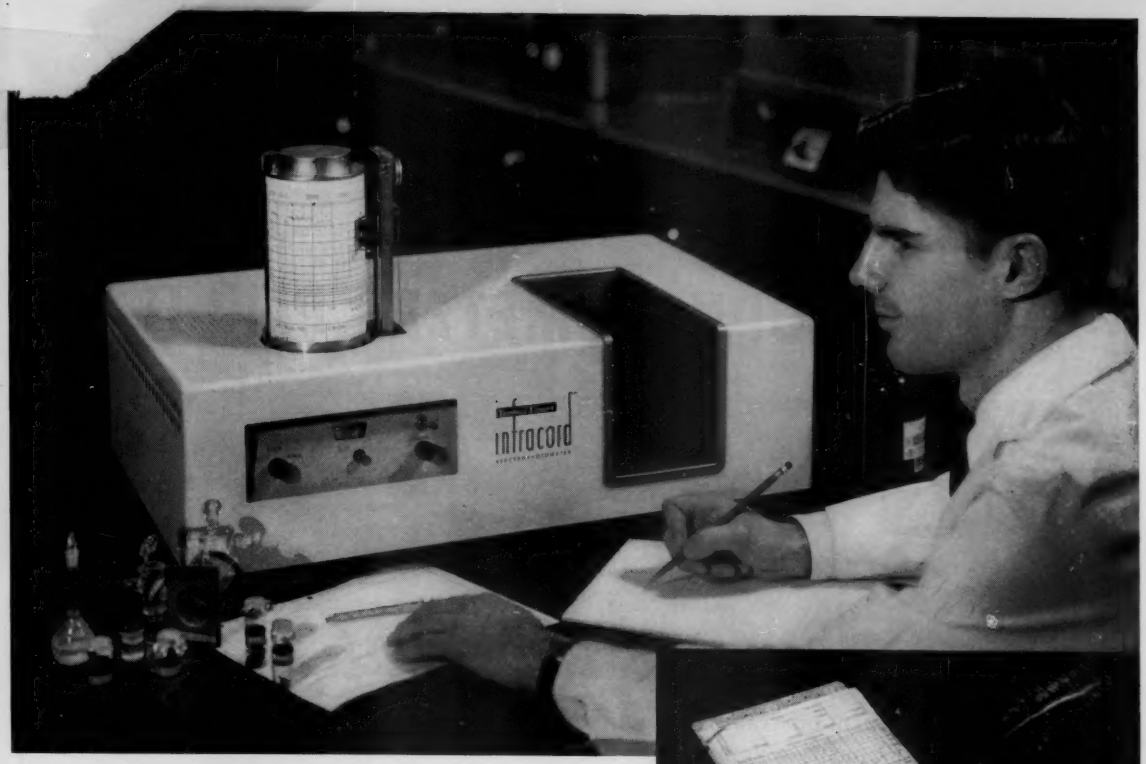


Low-Cost P-E Infracord Spectrophotometer*

PRESENTS ITS DATA AS YOU LIKE IT

The Perkin-Elmer Model 137 Infracord is a *double beam* spectrophotometer especially designed to give the bench chemist fast, accurate, easily interpreted data for his notebook. At a price of $3850, here's what the Infracord offers you:

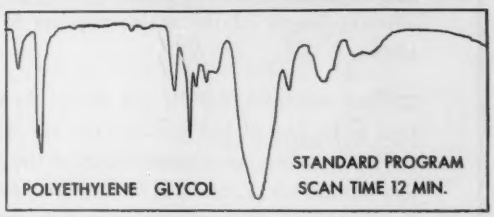
SPEED — The Infracord 137 makes a *full spectrum scan in 12 minutes.* Manual scan — for fast, simple analyses — can be done *in one minute.* Return to start takes one second.

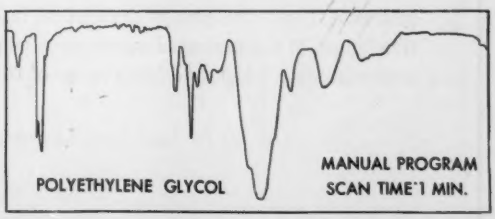
CONVENIENCE — The Infracord 137 features an easily accessible recording drum; removal is quick and simple. Spare drums may be loaded ahead of time, allowing the Infracord to be operated almost without a halt during rush periods.

EASE OF INTERPRETATION — The Infracord 137 presents its data in the standard form used by the API and Patent Office, simplifying spectra comparison. The 8½ by 11″ recording paper fits conveniently into notebooks, files, duplicating machines. The Infracord's sensitive recording mechanism accurately transcribes all the data obtainable from the instrument's fine double beam optics.

For further information on how the P-E Infracord 137 can help *your* analytical program, write us at 910 Main Ave., Norwalk, Conn.

* T.M.





Spectra above illustrate ability of Infracord to provide fast answers when necessary. Lower spectrum was obtained in one minute by manual rotation of the drum. Note close correlation with standard 12 minute run.

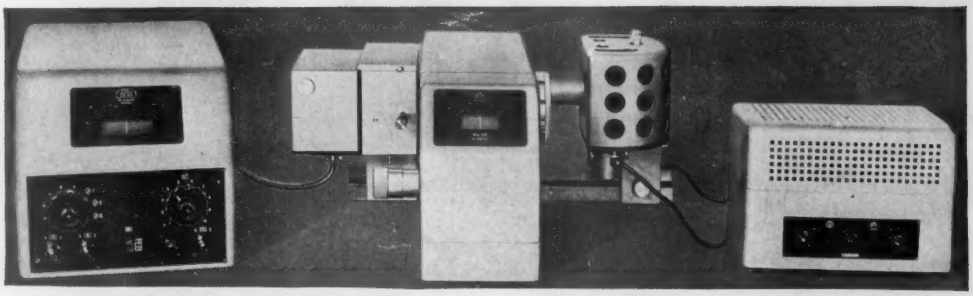
INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT

MADE BY CARL ZEISS IN WEST GERMANY

SPECTROPHOTOMETER PMQ II

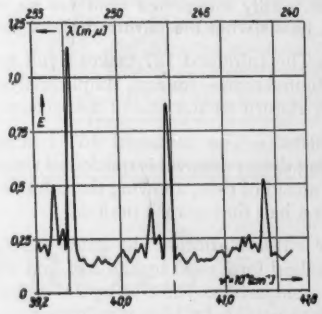


This new instrument offers universal applications for rapid, reliable and accurate photometric measurements of liquids, gases and solids at the highest resolving power of the spectrum.

The spectral region ranges from far-ultraviolet 200 mμ to near-infrared 1,000 mμ (2,500 mμ by using a lead sulphide cell). The instrument operates directly on 110-volt A.C. By means of a combined magnetic and electronic voltage stabilizer, fluctuations of + 10% to – 15% can be compensated. The transmission and extinction scales are projected on a ground glass window. The effective length of the scales appears to be approximately 16 inches.

The adjustment of the slit and that of the wave-length is guaranteed to be free of lost-motion. The slit width can be set within 0.2 mμ absolute. As a consequence of the friction-free design, no lost-motion is evident when setting the wave-length. For instance, the combined error of setting and reading the wave-length is guaranteed to be no greater than ± 0.05 mμ at 250 mμ. The effective length of the projected micro wave length scale appears to be approximately 4 feet, and has a range of from 200 mμ to 2,500 mμ.

Write for free, detailed specifications



Extinction curve of benzine vapor

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